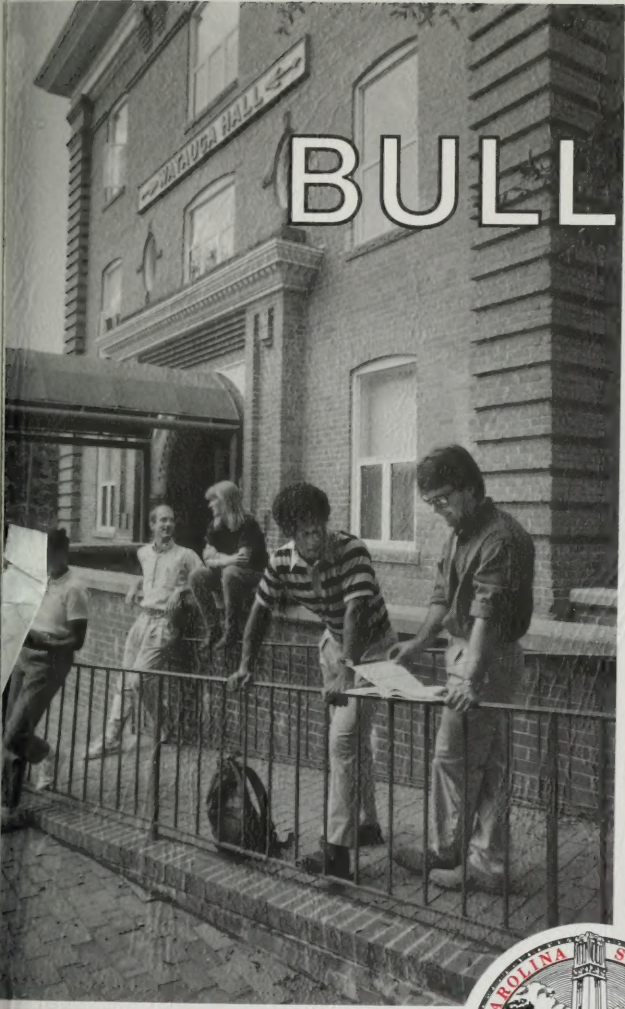


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BULLETIN



1990-1992 GRADUATE CATALOG

NORTH CAROLINA STATE UNIVERSITY

DECEMBER 1989



Above is an aerial view of the central campus of North Carolina State University viewed east to west. The strong diagonal in the foreground is Hillsborough Street which forms the north border. In the lower left is the Memorial Tower, a prominent landmark which commemorates World War I dead.

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North Carolina State University
Raleigh, North Carolina

Graduate Catalog
1990-92



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NORTH CAROLINA STATE UNIVERSITY

North Carolina State University is a national center for research, teaching and extension. As a Land-Grant state university, it shares the distinctive characteristics of these institutions nationally—broad academic offerings, extensive public service, national and international activities, and large-scale extension and research programs.

North Carolina State University is committed to equality of educational opportunity and does not discriminate against applicants, students or employees based on race, color, national origin, religion, sex, age or handicap. Moreover, NCSU is open to people of all races and actively seeks to promote racial integration by recruiting and enrolling a larger number of black students.

NCSU's rich and varied academic program is comprised of 96 undergraduate degree programs spanning 89 fields of study, 107 master's degree programs spanning 77 fields of study, 48 doctoral degree programs and the doctor of veterinary medicine program. The University offers approximately 2,900 courses.

Research activities span a broad spectrum of about 1,400 scientific, technological and scholarly endeavors with a budget of \$150 million annually.

Extension offices in each of the state's 100 counties and on the Cherokee Indian reservation assist in carrying the University's teaching and research programs throughout the state. The diversity of these programs spans such fields as agriculture, design, education, engineering, forestry, humanities, marine and environmental sciences, textiles, veterinary medicine, and the physical, social and life sciences.

The University's annual expenditures reach approximately \$425 million, and its employees total about 5,600. There are more than 2,950 faculty and professional staff, including 1,636 graduate faculty and 257 adjunct faculty.

NCSU's campus, located just west of the downtown area of Raleigh, totals some 1,750 acres. This includes the central campus of 623 acres with some 155 buildings, the adjacent Centennial Campus of 938 acres under development, and the 182-acre College of Veterinary Medicine campus.

In addition, the University has some 88,000 acres statewide, including one research and endowment forest of 78,000 acres. Near the campus are 2,500 acres containing research farms; biology and ecology sites; genetics, horticulture and floriculture nurseries; teaching and research forests; and Carter-Finley Stadium.

With a total enrollment of more than 25,500, the University has approximately 17,300 undergraduate students, 3,550 graduate students, 4,100 lifelong education students and 550 students in other special categories. The student population consists of approximately 15,600 men and 9,900 women, including 2,380 blacks and 888 other minority students. Students come to NCSU from every state in the union and at least 91 foreign countries are represented by 1,049 international students.

The University is organized in eight colleges, the School of Design and the Graduate School. The eight colleges are Agriculture and Life Sciences, Education and Psychology, Engineering, Forest Resources, Humanities and Social

Sciences, Physical and Mathematical Sciences, Textiles, and Veterinary Medicine. In addition, a complex of divisions and programs provides for a wide range of special programs in academic affairs, research and extension.

North Carolina State University is one of three Research Triangle Universities along with Duke University and the University of North Carolina at Chapel Hill. In the 30-mile triangle formed by the universities is the Research Triangle Park which includes the Research Triangle Institute, a not-for-profit, contract research organization founded by the three universities.

NCSU is a member of the National Association of State Universities and Land-Grant Colleges. It is also a member of the American Council on Education, the College Entrance Examination Board, the Council of Graduate Schools in the United States, the National Commission on Accrediting and the Southern Association of Colleges and Schools.

The University is accredited by national and regional accrediting agencies applicable to the University and its numerous professional fields.

Nondiscrimination Statement

North Carolina State University is dedicated to equality of opportunity within its community. Accordingly, North Carolina State University does not practice or condone discrimination, in any form, against students, employees or applicants on the grounds of race, color, national origin, religion, sex, age or handicap. North Carolina State University commits itself to positive action to secure equal opportunity regardless of those characteristics.

North Carolina State University supports the protection available to members of its community under all applicable Federal laws, including Titles VI and VII of the Civil Rights Act of 1964, Title IX of the Education Amendments of 1972, Sections 799A and 845 of the Public Health Service Act, the Equal Pay and Age Discrimination Acts, the Rehabilitation Act of 1973, the Vietnam Veterans Readjustment Assistance Act of 1974, and Executive Order 11246. For information concerning these provisions, contact:

Dr. Lawrence M. Clark
Associate Provost & Affirmative Action Officer
201 Holladay Hall
P. O. Box 7101
North Carolina State University
Raleigh North Carolina 27695-7101
Phone: 919/737-3409

ADMINISTRATION

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Nash N. Winstead, *Provost and Vice Chancellor*
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Terrence M. Curtin, *Veterinary Medicine*

Graduate School—Administrative Office

D. W. Stewart, *Dean*
E. M. Crawford, *Associate Dean*
D. A. Emery, *Associate Dean*

Graduate School—Administrative Board

Term Expires

D. W. Stewart, <i>Dean</i>	
E. M. Crawford, <i>Associate Dean</i>	
D. A. Emery, <i>Associate Dean</i>	
R. D. Bereman, <i>Professor of Chemistry; Associate Dean for Academic Affairs, College of Physical and Mathematical Sciences</i>	June, 1990
G. Bizios, <i>Professor of Architecture</i>	August, 1989
S. E. Elmaghraby, <i>University Professor of Industrial Engineering and Operations Research; Director of the Operations Research Program</i>	December, 1989
H. A. Exum, <i>Associate Professor of Counselor Education; Associate Dean for Research and Graduate Studies, College of Education and Psychology</i>	June, 1991
R. M. Fearn, <i>Professor of Economics and Business</i>	April, 1993
T. H. Glisson, <i>Professor of Electrical and Computer Engineering; Associate Dean for Academic Affairs, College of Engineering</i>	June, 1990
S. P. Hersh, <i>Charles A. Cannon Professor of Textile Engineering, Chemistry and Science; Director of Graduate Studies, College of Textiles</i>	September, 1992
E. J. Kamprath, <i>William Neal Reynolds Professor of Soil Science</i>	June, 1991
G. E. Mitchell, <i>Professor of Physics; Associate Head of the Department and Graduate Administrator</i>	March, 1991
R. G. Pearson, <i>Professor of Wood and Paper Science and Graduate Administrator</i>	June, 1991
M. C. Roberts, <i>Professor of Food Animal and Equine Medicine</i>	December, 1991
R. S. Sowell, <i>Professor of Biological and Agricultural Engineering and Graduate Administrator</i>	November, 1989
E. S. Vasu, <i>Associate Professor of Curriculum and Instruction</i>	June, 1991

THE CALENDAR

FALL SEMESTER, 1989

August 23	Wed.	First day of classes.
September 4	Mon.	Holiday.
September 7	Thurs.	Last day to register or to add a course; last day to withdraw or drop a course with a refund. (The tuition and fees charge is based on the official number of hours and courses carried at 5:00 p.m. on this day.)
September 20	Wed.	Last day to withdraw or drop a course at the 400 level or below without a grade.
October 2	Fri.	Academic Difficulties Reports due.
October 4	Wed.	Honors Convocation (no classes until 12:00 noon).
October 13	Fri.	Fall vacation begins at 1:00 p.m.
October 18	Wed.	Classes resume at 7:50 a.m.
October 27	Fri.	Last day to withdraw or drop a course at the 500 or 600 level without a grade.
November 10	Fri.	<i>Deadline for submission of theses to the Graduate School, in final form as approved by advisory committees, by candidates for master's and doctoral degrees in December, 1989. Last day for unconditional pass on final oral examinations by candidates for master's degrees not requiring theses.</i>
November 21	Tues.	Thanksgiving vacation begins at 1:00 p.m.
November 27	Mon.	Classes resume at 7:50 a.m.
December 8	Fri.	Last day of classes.
December 11-16	Mon.-Sat.	Final examinations.
December 18-19	Mon.-Tues.	Final examinations.

SPRING SEMESTER, 1990

January 10	Wed.	First day of classes.
January 15	Mon.	Holiday
January 25	Thurs.	Last day to register or to add a course; last day to withdraw or drop a course with a refund. (The tuition and fees charge is based on the official number of hours and courses carried at 5:00 p.m. on this day.)
February 8	Thurs.	Last day to withdraw or drop a course at the 400 level or below without a grade.
February 21	Wed.	Academic Difficulties Reports due.
March 2	Fri.	Spring vacation begins at 10:00 p.m.
March 12	Mon.	Classes resume at 7:50 a.m.
March 16	Fri.	Last day to withdraw or drop a course at the 500 or 600 level without a grade.

March 30	Fri.	<i>Deadline for submission of theses to the Graduate School, in final form as approved by advisory committees, by candidates for master's and doctoral degrees in May, 1990. Last day for unconditional pass on final oral examinations by candidates for master's degrees not requiring theses.</i>
April 13	Fri.	Holiday
April 27	Fri.	Last day of classes.
April 30-May 5	Mon.-Sat.	Final examinations.
May 7-8	Mon.-Tues.	Final examinations.
May 12	Sat.	Commencement.

SUMMER SESSIONS, 1990

First Session

May 22	Tues.	First day of classes.
May 28	Mon.	Last day to register or to add a course; last day to withdraw or drop a course with a refund. (The tuition and fees charge is based on the official number of hours and courses carried at 5:00 p.m. on this day.)
June 1	Fri.	Last day to withdraw or drop a course at the 400 level or below without a grade.
June 8	Fri.	Last day to withdraw or drop a course at the 500 or 600 level without a grade.
June 22	Fri.	Last day of classes.
June 25-26	Mon.-Tues.	Final examinations.

Second Session

July 2	Mon.	First day of classes.
July 4	Wed.	Holiday
July 6	Fri.	<i>Deadline for submission of theses to the Graduate School, in final form as approved by advisory committees, by candidates for master's and doctoral degrees in August, 1990. Last day for unconditional pass on final oral examinations by candidates for master's degrees not requiring theses.</i>
July 9	Mon.	Last day to register or to add a course; last day to withdraw or drop a course with a refund. (The tuition and fees charge is based on the official number of hours and courses carried at 5:00 p.m. on this day.)
July 13	Fri.	Last day to withdraw or drop a course at the 400 level or below without a grade.
July 20	Fri.	Last day to withdraw or drop a course at the 500 or 600 level without a grade.

August 3	Fri.	Last day of classes.
August 6-7	Mon.-Tues.	Final examinations.

FALL SEMESTER, 1990

August 22	Wed.	First day of classes.
September 3	Mon.	Holiday.
September 10	Mon.	Last day to register or to add a course; last day to withdraw or drop a course with a refund. (The tuition and fees charge is based on the official number of hours and courses carried at 5:00 p.m. on this day.)
September 24	Mon.	Last day to withdraw or drop a course at the 400 level or below without a grade.
October 3	Wed.	Honors Convocation (no classes until 12:00 noon)
October 5	Fri.	Academic Difficulties Reports due.
October 12	Fri.	Fall vacation begins at 1:00 p.m.
October 17	Wed.	Classes resume at 7:50 a.m.
October 26	Fri.	Last day to withdraw or drop a course at the 500 or 600 level without a grade.
November 9	Fri.	<i>Deadline for submission of theses to the Graduate School, in final form as approved by advisory committees, by candidates for master's and doctoral degrees in December, 1990. Last day for unconditional pass on final oral examinations by candidates for master's degrees not requiring theses.</i>
November 21	Wed.	Thanksgiving vacation begins at 1:00 p.m.
November 26	Mon.	Classes resume at 7:50 a.m.
December 7	Fri.	Last day of classes.
December 10-15	Mon.-Sat.	Final examinations.
December 17-18	Mon.-Tues.	Final examinations.

SPRING SEMESTER, 1991

January 9	Wed.	First day of classes.
January 21	Mon.	Holiday
March 1	Fri.	Spring vacation begins at 10:00 p.m.
March 11	Mon.	Classes resume at 7:50 a.m.
March 28	Thurs.	<i>Deadline for submission of theses to the Graduate School, in final form as approved by advisory committees, by candidates for master's and doctoral degrees in May, 1991. Last day for unconditional pass on final oral examinations by candidates for master's degrees not requiring theses.</i>
March 29	Fri.	Holiday.
April 26	Fri.	Last day of classes.
April 29-May 3	Mon.-Sat.	Final examinations.

May 6-7	Mon.-Tues.	Final examinations.
May 11	Sat.	Commencement.

SUMMER SESSIONS, 1991

First Session

May 21	Tues.	First day of classes.
June 21	Fri.	Last day of classes.
June 24-25	Mon.-Tues.	Final examinations.

Second Session

July 1	Mon.	First day of classes.
July 4	Thurs.	Holiday.
July 5	Fri.	<i>Deadline for submission of theses to the Graduate School, in final form as approved by advisory committees, by candidates for master's and doctoral degrees in August, 1991. Last day for unconditional pass on final oral examination by candidates for master's degrees not requiring theses.</i>
August 2	Fri.	Last day of classes.
August 5-6	Mon.-Tues.	Final examinations.

NOTE: This calendar is subject to periodic review and revision.



The Graduate School

Graduate instruction was first offered at North Carolina State University in 1893, and the first doctoral degree was conferred in 1926. In the ensuing years, the Graduate School has grown steadily and now provides instruction and facilities for advanced study and research in the fields of agriculture and life sciences, design, education, engineering, forest resources, humanities and social sciences, physical and mathematical sciences, textiles and veterinary medicine. In 1988-89, the University granted 203 Doctor of Philosophy degrees, 29 Doctor of Education degrees and 639 master's degrees.

The Graduate School is currently composed of more than 1,700 graduate faculty members. Educated at major universities throughout the world and established both in advanced teaching and research, these scholars guide the University's more than 3,800 master's and doctoral students from all areas of the United States and some 91 other countries.

The faculty and students have available exceptional facilities, including libraries, laboratories, modern equipment and special research areas. Additionally, a cooperative agreement exists among the Graduate Schools of the University of North Carolina at Chapel Hill, the University of North Carolina at Greensboro, Duke University and North Carolina State University which increases the educational and research possibilities associated with each.

Graduate Student Association

The Graduate Student Association (GSA) is an academic, political and social organization composed of all graduate students and governed by duly elected officials and representatives from the departmental graduate student chapters. It is officially recognized by the university as the voice of the graduate students. The GSA President has full voting membership on the Graduate School Administrative Board.

Among the services that the GSA sponsors, one of its most viable academic programs is the Travel Fund. Through this fund graduate students may obtain funds to present original research work at professional meetings. The GSA also sponsors, along with the Alumni Association and the Academy of Outstanding Teachers, an annual awards ceremony to honor those teaching assistants of outstanding merit. In addition, the GSA, through its standing committees, sponsors various social events and provides support for departmental GSA chapters.

Generally, the GSA can provide assistance on most questions concerning graduate student life. Graduate students may contact GSA via their departmental representative or via the president of the Association whose telephone number can be obtained through the Graduate School. All graduate students are also invited to participate in the business meetings which are usually held on the last Monday of each month. Contact departmental representatives for time and place.

GENERAL INFORMATION

Application

Applications for admission must be accompanied by the following: two official transcripts from all colleges and universities previously attended, references from at least three people who know of the student's academic record and potential for graduate study, a non-refundable application fee of \$35 and, in most cases, an official statement of the student's Graduate Record Examination scores. Application and reference forms may be obtained by writing or visiting the Dean of the Graduate School, 104 Peele Hall, Box 7102, North Carolina State University, Raleigh, N. C. 27695-7102. When completed, all application materials should be returned according to instructions. Application is made for a specific degree program and date of enrollment (see "Admission").

Graduate Record Examination (GRE) Scores

The following departments and programs will not act on applications unless accompanied by GRE scores for at least the GRE General (Aptitude) Test (verbal and quantitative):

- *Adult and Community College Education

- *Agricultural Education

 - Aerospace Engineering

 - Animal Science

 - Biochemistry

 - Biomathematics

 - Botany

 - Chemical Engineering

 - Computer Engineering

 - Crop Science

 - Curriculum and Instruction

 - Ecology

- *Educational Administration and Supervision

 - Electrical Engineering

 - English

 - Entomology

 - Food Science

 - Forestry

 - Genetics

 - Guidance and Personnel Services

 - History

 - Horticultural Science

- *Industrial Arts Education

 - Industrial Engineering

 - International Development

 - Marine, Earth and Atmospheric Sciences

 - Mathematics

*These programs require either the GRE or Miller Analogies (the Mathematics and Science Education programs require both for doctoral).

- *Mathematics Education
- Mechanical Engineering
- Microbiology
- Nutrition
- *Occupational Education
- Physiology
- Plant Pathology
- Political Science
- Product Design
- **Psychology
- Public Affairs
- Recreation Resources Administration
- Rural Sociology
- *Science Education
- Sociology
- *Special Education
- Statistics
- Toxicology
- *Vocational Industrial Education
- Wildlife Biology
- ***Zoology

Many departments, although not normally requiring GRE scores, may in special instances require their submission as additional information to be used in making a judgment of the student's potential for success in a graduate program. Information regarding the GRE and registration forms may be obtained from the Educational Testing Service, Box 6000, Princeton, NJ 08541-6000.

*These programs require either the GRE or Miller Analogies (the Mathematics and Science Education programs require both for doctoral).

**Psychology requires the Subject (Advanced) Test and Miller Analogies as well.

***The Zoology program requires the GRE General and Advanced Test.

International Students

Students whose native language is other than English, regardless of citizenship, must submit TOEFL (Test of English as a Foreign Language) scores as evidence of ability to use English at a level of competence sufficient for graduate work. The minimum requirement for admission is a TOEFL score of 550, with scores of 50 on at least two of the sections and no section score below 45. (Minimum score subject to change; departments may establish a higher minimum requirement.) The test date must be within 24 months of the application deadline date before the semester for which the application is being reviewed. An *official* score report issued by the Educational Testing Service is required. All international students must be cleared by the Department of Foreign Languages and Literatures during the first two weeks of their initial semester in residence and may be required to take additional course work in English. In addition, the international applicant must provide the University with verification that the required funds are available to support the proposed program of advanced study. Foreign nationals in the United States at the time application is made must also provide information regarding their current visa status. The University provides special forms to be used by the applicant in supplying this information.

Admission

The procedures followed in evaluating an applicant's potential for success in graduate work and the criteria used for admissions decisions vary according to departments and colleges/schools and reflect an evaluation of the applicant's potential to engage in graduate work and the capability of the individual departments to accommodate additional students. Most departments consider applications as they arrive, while others accumulate applications and make recommendations on admission at certain times during the year. Generally, requests for admission are considered by departmental admissions committees which forward the departmental recommendations to the Dean of the Graduate School.

Students are admitted to full or provisional status in a specific degree program. Admission is granted for a specific semester or summer term. Any change in the admission date must be requested in writing and approved by the department and Graduate School. Once the requirements for that degree program have been completed, no further registration as a graduate student will be permitted unless admission to a new graduate classification has been formally approved. Students with special objectives may request admission in the "Graduate-Unclassified Status" (see below) or register in the "Post-Baccalaureate Studies" program (see next page) through the Division of Lifelong Education.

FULL GRADUATE STANDING

To be considered for admission in full graduate standing, an applicant must have a baccalaureate degree from a college or university recognized as standard by a regional or general accrediting agency and must have at least a "B" average in the undergraduate major or in the latest graduate degree program.

PROVISIONAL ADMISSION

1. Provisional admission may be granted to applicants with bachelor's degrees from accredited institutions who lack undergraduate work considered essential for graduate study in a major field. Course work, without graduate credit, will be required to make up such deficiencies before admission to full status can be granted.

Applicants with bachelor's degrees from nonaccredited institutions may be granted provisional admission when their academic records warrant this status. Additional course work will be required of such students when deficiencies in previous training are apparent.

Full graduate standing is granted when the deficiencies responsible for the provisional status are corrected, provided the student has maintained a satisfactory academic record (3.0 Grade Point Average) on all course work taken in a graduate classification. A change from provisional status to full graduate standing is effected only upon the recommendation of the department in which the student is seeking the degree.

2. Students with bachelor's degrees from accredited institutions whose scholastic records are below the standards for admission to full graduate standing may be admitted provisionally when unavoidable, extenuating circumstances affected their undergraduate averages or when progressive improvement in their undergraduate work warrants provisional admission. Students admitted provisionally under these circumstances will have their status changed to full

graduate standing after completion of nine or more graduate credit hours following admission provided the student has maintained at least a "B" average.

A graduate student is not eligible for appointment to an assistantship or fellowship while on provisional status.

GRADUATE-UNCLASSIFIED STATUS

The Graduate-Unclassified status is a temporary classification and students admitted to this status are not candidates for degrees. They may take courses for graduate credit but may not apply more than 10 credits earned while in this status to any program leading to an advanced degree at this institution. Unclassified graduate students are expected to meet the same admissions requirements that apply to graduate students in full standing. Any individual having an interest in applying for admission as a Graduate-Unclassified Student should correspond with the Graduate Dean describing his or her particular interests and objectives prior to making application.

POST-BACCALAUREATE STUDIES (PBS)

The Post-Baccalaureate Studies (PBS) classification is designed for U. S. citizens who wish to undertake academic work beyond the baccalaureate degree but who are not currently admitted to a degree program. This classification is not open to international students with the exception of the spouse of a regularly enrolled NCSU student. In special cases where students are sponsored by an agency of the U. S. government for specialized, non-degree study, approval may be given by the Graduate School for registration in the Post-Baccalaureate Studies classification. The following policies apply to students who wish to register for PBS:

1. All must have baccalaureate degrees from accredited institutions of higher education.
2. All classes taken for credit by PBS students will be graded in the usual manner that applies for the particular course (A,B,C,D,NC or S,U). All courses taken at NCSU will show on the student's transcript. If the student is admitted as a graduate student, a maximum of nine hours may apply toward the minimum requirements of the degree for which the student is enrolled, including hours approved for graduate credit while classified as a senior, unclassified undergraduate or professional engineering student. Only the *first* nine hours of course work taken at the graduate level in the PBS category can be accepted toward degree requirements unless a request for some other combination of nine hours is made by the student's advisory committee and approved both by the College or School Dean and the Graduate Dean.
3. The grade point average (GPA) of a graduate student who has credits in the PBS category will be based on all courses taken at the 400-600 level. However, no course taken six (6) years prior to enrollment into a program will be considered in the GPA calculation.
4. Registration is limited to a maximum of two courses per semester. Individuals who are employed full-time should limit their PBS registrations to one course per semester.

5. The PBS classification carries with it no implication that the student will be admitted to the Graduate School in any degree classification.
6. All course work accepted for degree credit must be approved by the student's advisory committee as being germane to the program. Requests for degree credit for courses completed in the PBS classification are considered after admission to a graduate degree program when the student's Plan of Graduate Work is filed with the Graduate School.
7. PBS students are expected to familiarize themselves with Graduate School policies and to seek further advice or clarification as needed.

Grades of all courses taken after the first nine hours will be recorded on PBS students' transcripts.

COLLEGE OF ENGINEERING PROFESSIONAL DEGREE PROGRAM

Professional degree students are admitted as undergraduate students, are classified as "PR" students and are subject to rules and regulations as established and administered by the Dean of the College of Engineering.

A professional degree student who is subsequently admitted to the Graduate School may, with the approval of the master's advisory committee, the major department and the Graduate School receive graduate credit for a maximum of nine hours credit for courses in which a grade of "B" or higher was received.

COOPERATIVE EDUCATION PROGRAM

The Cooperative Education Program is designed to be an integral part of a graduate student's educational program and is available to all majors. The program is designed to complement classroom learning by providing sponsored, paid work assignments in industry, business, and government. The work experience is selected in terms of its relationship to a student's major and/or career goals and provides for full-time work on alternating semesters or part-time work on a parallel plan while carrying a reduced load of courses. Co-op participation does not constitute an interruption of college work. Co-op work assignments have been approved and are monitored by the program staff.

To be eligible for the Co-op Program, graduate students must have completed one semester of graduate study, be in good academic standing, have the approval of their graduate advisers, and have an interview with the Director of Cooperative Education. For program completion, graduate students must work a minimum of one fall or spring semester full-time or two semesters part-time. However, most employers look for an increased level of productivity on the part of the student and, therefore, expect the graduate student to plan on additional work semesters.

International students also qualify for the Co-op Program provided they meet visa regulations on curricular practical training.

For further information, contact William D. Weston, Director of Cooperative Education, Box 7110, 737-2199.

COOPERATING RALEIGH COLLEGES

The Cooperating Raleigh Colleges (CRC) is a voluntary organization comprised of North Carolina State University, Meredith College, Peace College, St. Augustine's College, St. Mary's College and Shaw University. Graduate pro-

grams are currently offered only at NCSU and Meredith College, but the organization provides the opportunity for graduate students to enroll at either institution for a course or courses not offered on their home campus.

Any NCSU graduate degree student who is enrolled in at least three graduate credit hours on the NCSU campus may take a course at Meredith College during the fall or spring semester, provided that (a) the course is not taught on the NCSU campus and (b) the advisory committee considers the course educationally desirable.

NCSU students may not register for more than a total of two courses in any semester at Meredith, and no more than six of the required academic credits for a master's degree at NCSU may be accepted from that institution. Grades from Meredith are not used in computing a student's NCSU grade point average.

Under this agreement, regular tuition and fees are paid to NCSU. Certain special fees may be required for specific courses at Meredith, and the student is responsible for paying these fees.

Certificate Renewal

Public school personnel who are primarily interested in "certification credit" may enroll in the PBS program through the Division of Lifelong Education without forwarding transcripts of previous work to the Graduate School. In such cases, the College of Education and Psychology will be responsible for assessing the adequacy of the applicant's qualifications for enrollment in the course(s) concerned.

Registration and Records

The Office of Registration and Records must have authorization from the Dean of the Graduate School before a graduate student in any classification will be permitted to register for classes. This authorization will be sent to the Office of Registration and Records at the time the student is notified of acceptance for graduate study. All students attending classes must be registered for credit or audit. Grade records are furnished the students at the end of each scheduled school term.

MEDICAL HISTORY AND IMMUNIZATION RECORDS

All graduate students admitted to a degree program are required by State law to submit a report of medical history and immunization documentation prior to completing their initial registration. This report must document immunization against tetanus, measles, German measles and polio. NCSU students returning to Graduate School must have their medical history on file updated. The required reports should be received in the Student Health Service at least thirty days before registration.

INTERINSTITUTIONAL REGISTRATION

North Carolina State University participates in an Interinstitutional Registration program with the University of North Carolina at Chapel Hill, the University of North Carolina at Greensboro and Duke University. Under this agreement, graduate students enrolled at this university may undertake course

work on these campuses upon the recommendation of their advisory committees. Courses offered by North Carolina A&T University and by the University of North Carolina at Charlotte over the Microelectronics Center of North Carolina communications system are also available through Interinstitutional Registration.

Even though taking a course on another campus, the graduate student is exclusively under the administrative direction of the North Carolina State University Graduate School. Enrollment for courses on other campuses will take place on this campus, using special forms obtained from the Office of Registration and Records. The Graduate School shall consider courses taken on other campuses as a part of the student's normal load, and the billing for such work will be through the Office of Finance and Business. The procedures followed in the summer sessions are somewhat different; detailed instructions are available in the Office of Registration and Records.

When the grading system on the campus being visited is different from the North Carolina State University system, grades received under Interinstitutional Registration will be converted to the North Carolina State University system. "H," "P," "L" and "F" grades earned at the University of North Carolina at Chapel Hill and "E," "G," "S" and "F" grades earned at Duke University will be converted to "A," "B," "C" and "NC" grades, respectively.

COURSE LOAD

A full-time graduate course load is 9 to 15 credits per semester (including audits) and 6 credits per summer session (including audits). Audits in subjects in which the student has no previous experience will be evaluated at full credit value in determining course load. Audits taken as repetition of work previously accomplished are considered at one half of their value in calculating course loads. With the single exception of foreign language audits, all audit registrations must fall within the range of maximum permissible course loads.

Foreign students on F-1 and J-1 visas are required by the Immigration and Naturalization Service to carry a full-time course of study to remain in status.

Graduate students holding assistantships are restricted to the following maximum semester course loads: full time, 3 hours; three-quarters time, 6 hours; one-half time, 9 hours; one-quarter time, 12 hours. External employment obligations of students on assistantships plus their assistantship obligations should not exceed these limits. Additionally, graduate assistants are limited to the following maximum totals of credit hours over the duration of their appointments:

<i>Assistantship Classification</i>	<i>Length of Appointment</i>	<i>Maximum Credit Hours</i>
Full time	9 months	6
Full time	12 months	9
$\frac{3}{4}$ time	9 months	12
$\frac{3}{4}$ time	12 months	16
$\frac{1}{2}$ time	9 months	18
$\frac{1}{2}$ time	12 months	24
$\frac{1}{4}$ time	9 months	24
$\frac{1}{4}$ time	12 months	30

SENIORS

A member of the senior class may, with prior approval of the Dean of the Graduate School, register for graduate credit in courses at the 400 and 500 levels as long as the combined graduate and undergraduate credit load is not more than 15 hours. Seniors with an accumulated grade point average of 3.2 or better in their major may enroll for a combined graduate and undergraduate credit load of 18 hours upon the recommendation of the student's advisor and approval by the department and the Graduate School. No more than six hours of graduate credit may be accumulated by a senior, and those graduate credits may not be applied toward the requirements for a baccalaureate degree. Courses at the 600 level are not ordinarily open to undergraduates, although occasional exceptions are made for senior honor students.

Seniors desiring to take courses for graduate credit should contact their major advisers who will forward appropriate requests to the Graduate Dean for approval.

AUDITS

Students wishing to audit courses must have the approval of their advisers and of the instructors teaching the courses. While auditors receive no course credit, they are expected to attend class regularly. The degree to which auditors must participate in class beyond regular attendance is optional with the instructors; any such requirements should be clearly explained to the auditors in writing at the beginning of the semester. An instructor who feels that an auditor has failed to fulfill the stipulated requirements is justified in marking "NR" (no recognition given for audit) on the grade report roll.

GRADUATION

There are three official graduations for graduate students per year, occurring at the end of the fall and spring semesters and at the end of the second summer session. Formal commencement exercises are held only at the end of spring semester, but any student who graduated the preceding second summer session or fall semester is eligible to participate if he or she notifies the Graduate School in writing of such an intent at least four weeks in advance of the actual commencement date. Conversely, any student scheduled to graduate in the spring semester is required to attend commencement unless he or she has notified the Graduate School in writing of the desire to have the degree conferred *in absentia*.

The diplomas for those students graduating at the end of second summer session or fall semester and those receiving permission to receive the degree *in absentia* are mailed by the Office of Registration and Records which is also responsible for the ordering of diplomas.

Tuition and Fees

A statement of tuition and fees is mailed to each preregistered student approximately five weeks before the beginning of any term. The statement must be returned with full payment or complete financial assistance information by the due date appearing on the statement. Normally the due date is approximately

two weeks before classes begin. Non-preregistered students are required to pay their tuition and fees at registration.

All students are responsible for tuition appropriate to their residence status unless payment is specifically provided by the terms of a fellowship, traineeship or assistantship.

SEMESTER RATE SCHEDULE—1989-90 ACADEMIC YEAR

	RESIDENTS OF NORTH CAROLINA*	NONRESIDENTS**
<i>Hours</i>	<i>Tuition and Fees</i>	<i>Tuition and Fees</i>
0-Thesis	\$150	\$ 470
0-2	150	712
3-5	225	1,351
6-8	225	2,064
9+	525	2,776

SUMMER SESSION RATE SCHEDULE—1990

	RESIDENTS OF NORTH CAROLINA	NONRESIDENTS
<i>Hours</i>	<i>Tuition and Fees</i>	<i>Tuition and Fees</i>
0-Thesis	\$150	\$ 470
0-2	150	712
3-5	225	1,351
6-8	301	1,989
9+	376	2,627

SPECIAL REGISTRATION AND FEES—1989-90 ACADEMIC YEAR

****Summer Research [GR 596S (master's candidates) or GR 696S (doctoral candidates)]*

For graduate students whose programs of work specify no formal course work during a summer session and who will be devoting full time to thesis research.

*For definition of in-state and out-of-state rates, see pp. 23-25.

**Under certain conditions, nonresident students who have been offered an assistantship, traineeship or fellowship may be eligible for reduced tuition rates.

***Assessed the 0-Thesis rate.

North Carolina. Free tuition privileges do not apply during the summer. Each applicant for free tuition must submit through regular channels a form provided by the University.

REFUND OF TUITION AND FEES

A student who officially withdraws from school during the first two weeks of a semester or by the end of the fourth day of a summer session will receive a tuition and fees refund of the full amount paid less a registration fee. The withheld fee amounts to \$15 the first week and \$25 the second week. After the two-week period, no refund will be made.

In some instances, circumstances justify the waiving of rules regarding refunds. An example might be withdrawal because of sickness. Students have the privilege of appeal to the Fee Appeals Committee when they feel special consideration is merited. Applications for such appeals may be obtained from the University Cashier and Student Accounts Office, 1101 Student Services Center.

RESIDENCE STATUS FOR TUITION PURPOSES

The basis for determining the appropriate tuition charge rests upon whether a student is a resident or a nonresident for tuition purposes. Each student must make a statement as to the length of his or her residence in North Carolina with assessment by the institution of that statement to be conditioned by the following:

Residence—To qualify as a resident for tuition purposes, a person must become a legal resident and remain a legal resident for at least twelve months immediately prior to classification. Thus, there is a distinction between legal residence and residence for tuition purposes. Furthermore, twelve months' legal residence means more than simple abode in North Carolina. In particular, it means maintaining a domicile (permanent home of indefinite duration) as opposed to "maintaining a mere temporary residence or abode incident to enrollment in an institution of higher education." The burden of establishing facts which justify classification of a student as a resident entitled to in-state tuition rates is on the applicant for each classification, who must show his or her entitlement by the preponderance (the greater part) of the residentiary information.

Initiative—Being classified a resident for tuition purposes is contingent on the student's seeking such status and providing all information that the institution may require in making the determination.

Parents' Domicile—If an individual, irrespective of age, has living parent(s) or court-appointed guardian of the person, the domicile of such parent(s) or guardian is, *prima facie*, the domicile of the individual; but this *prima facie* evidence of the individual's domicile may or may not be sustained by other information. Further, nondomiciliary status of parents is not deemed *prima facie* evidence of the applicant child's status if the applicant has lived (though not necessarily legally resided) in North Carolina for the five years preceding enrollment or re-registration.

Effect of Marriage—Marriage alone does not prevent a person from becoming or continuing to be a resident for tuition purposes, nor does marriage in any circumstance insure that a person will become or continue to be a resident for tuition purposes. Marriage and the legal residence of one's spouse are, however, relevant information in determining residency intent. Furthermore, if both a husband and his wife are legal residents of North Carolina and if one of them has been a legal resident longer than the other, then the longer duration may be claimed by either spouse in meeting the twelve-month requirement for in-state tuition status.

Military Personnel—A North Carolinian who serves outside the State in the armed forces does not lose North Carolina domicile simply by reason of such service. Students from the military may prove retention or establishment of residence by reference, as in other cases, to residency acts accompanied by residency intent.

In addition, a separate North Carolina statute affords tuition rate benefits to certain military personnel and their dependents even though not qualifying for the in-state tuition rate by reason of twelve months legal residence in North Carolina. Members of the armed services, while stationed in and concurrently living in North Carolina, may be charged a tuition rate lower than the out-of-state tuition rate to the extent that the total of entitlements for applicable tuition costs available from the federal government, plus certain amounts based under a statutory formula upon the in-state tuition rate, is a sum less than the out-of-state tuition rate for the pertinent enrollment. A dependent relative of a service member stationed in North Carolina is eligible to be charged the in-state tuition rate while the dependent relative is living in North Carolina with the service member and if the dependent relative has met any requirement of the Selective Service System applicable to the dependent relative. These tuition benefits may be enjoyed only if the applicable requirements for admission have been met; these benefits alone do not provide the basis for receiving those derivative benefits under the provisions of the residence classification statute reviewed elsewhere in this summary.

Grace Period—If a person (1) has been a bona fide legal resident, (2) has consequently been classified a resident for tuition purposes and (3) has subsequently lost North Carolina legal residence while enrolled at a public institution of higher education, that person may continue to enjoy the in-state tuition rate for a grace period of twelve months measured from the date on which North Carolina legal residence was lost. If the twelve months end during an academic term for which the person is enrolled at a State institution of higher education, the grace period extends, in addition, to the end of that term. The fact of marriage to one who continues domiciled outside North Carolina does not by itself cause loss of legal residence, marking the beginning of the grace period.

Minors—Minors (persons under 18 years of age) usually have the domicile of their parents, but certain special cases are recognized by the residence classification statute in determining residence for tuition purposes.

(a) If a minor's parents live apart, the minor's domicile is deemed to be North Carolina for the time period(s) that either parent, as a North Carolina legal resident, may claim and does claim the minor as a tax dependent, even if other law or judicial act assigns the minor's domicile outside North Carolina. A minor thus deemed to be a legal resident will not, upon achieving majority before

enrolling at an institution of higher education, lose North Carolina legal residence if that person (1) upon becoming an adult “acts, to the extent that the person’s degree of actual emancipation permits, in a manner consistent with bona fide legal residence in North Carolina” and (2) “begins enrollment at an institution of higher education not later than the fall academic term next following completion of education prerequisite to admission at such institution.”

(b) If a Minor has lived for five or more consecutive years with relatives (other than parents) who are domiciled in North Carolina and if the relatives have functioned during this time as if they were personal guardians, the minor will be deemed a resident for tuition purposes for an enrolled term commencing immediately after at least five years in which these circumstances have existed. If under this consideration a minor is deemed to be a resident for tuition purposes immediately prior to his or her eighteenth birthday, that person on achieving majority will be deemed a legal resident of North Carolina of at least 12 months’ duration. This provision acts to confer in-state tuition status even in the face of other provisions of law to the contrary; however, a person deemed a resident of 12 months’ duration pursuant to this provision continues to be a legal resident of the State only so long as he or she does not abandon North Carolina domicile.

Lost but Regained Domicile—If a student ceases enrollment at or graduates from an institution of higher education while classified a resident for tuition purposes and then both abandons and reacquires North Carolina domicile within a 12-month period, that person, if he or she continues to maintain the reacquired domicile into re-enrollment at an institution of higher education, may re-enroll at the in-state tuition rate without having to meet the usual 12-month durational requirement. However, any one person may receive the benefit of this provision only once.

Change of Status—A student admitted to initial enrollment in an institution (or permitted to re-enroll following an absence from the institutional program which involved a formal withdrawal from enrollment) must be classified by the admitting institution either as a resident or as a non-resident for tuition purposes prior to actual enrollment. A residence status classification once assigned (and finalized pursuant to any appeal properly taken) may be changed thereafter (with corresponding change in billing rates) only at intervals corresponding with the established primary divisions of the academic year.

Transfer Students—When a student transfers from one North Carolina public institution of higher education to another, he or she is treated as a new student by the institution to which he or she is transferring and must be assigned an initial residence status classification for tuition purposes.

Prevailing North Carolina Law—General Statute (G.S.) 116-143.1 is the prevailing statute governing residence status classification. Copies of the applicable law and/or implementing regulations are available for inspection in the Office of Undergraduate Admissions, 112 Peele Hall.

To initiate a review of a residence status classification, a student must submit a Residence-and-Tuition Status Application to the Graduate School office, 104 Peele Hall. Questions about residency should be directed to that office.

Fellowships and Graduate Assistantships

Graduate students may receive financial support through fellowships, traineeships and teaching or research assistantships sponsored by federal, state and

private agencies. Prospective students may request consideration for financial assistance by completing the appropriate sections of the admissions application form. Applicants for these awards should correspond directly with the department of major interest concerning the availability of awards and related information. Enrolled students should contact the major department. Prospective and enrolled graduate students are encouraged to apply for national, regional and foundation fellowships in addition to awards sponsored through the University.

RESEARCH AND TEACHING ASSISTANTSHIPS

The University offers approximately 1,760 assistantships each year. Stipend rates for teaching and research assistantships are competitive with other universities. For further information on the availability of assistantships, applicants should contact the program area of interest.

Unless tuition is expressly provided by the terms of the award, an award recipient must pay tuition at the rate determined by his or her residence status. However, a nonresident graduate student awarded an assistantship or a fellowship may be eligible for a reduced tuition rate comparable to the in-state rate. Further information may be obtained by contacting the department of major interest.

A graduate student must be in good academic standing (B or better average) to be eligible for appointment to an assistantship, fellowship or traineeship and must be registered in each semester in which the appointment is in effect. This also means that if an assistantship holder covered by tuition remission terminates his/her studies after the last day to withdraw from the University or to drop a course with a refund (approximately seven days after classes commence), that student will be responsible for the prorated part of tuition and fees.

DEPARTMENTAL FELLOWSHIPS

Several departments offer fellowships funded from private sources. Students are nominated for these fellowships by their departments or programs with selection being made by faculty committees or by the Graduate School. For additional information concerning such fellowships, the applicant should contact the appropriate college, department or program. Examples of such fellowships are listed below:

PHY Training Grant, USDA National Needs Fellowship, Biotechnology Fellowship and Purina Mills Research Fellowship, all through the College of Agriculture and Life Sciences; Dairyman Inc. Fellowship in the Department of Animal Science; Pioneer Hybred International in the Department of Crop Science; Chemical Industries Institute for Toxicology through the Toxicology Program; Fellowship through the Department of Plant Pathology; E. G. Moss and R. J. Reynolds Fellowships through the N. C. Agricultural Research Service in the College of Agriculture and Life Sciences; Harkema Fellowship in the Department of Zoology; NASA Traineeship, Eastman Scholarship and ARO Fellowships in the Department of Mechanical and Aerospace Engineering; Nuclear Energy Fellowship, Fusion Technology Fellowship and Murray Fellowship through the Department of Nuclear Engineering; Dupont Manufacturing Systems Fellowship through the Integrated Manufacturing Systems Engineering

Institute; Kimley-Horn Graduate Scholarship and Carolina Asphalt Association, Inc., through the Department of Civil Engineering; ECE Levels I, II and III Supplementary Fellowships, IBM Graduate Fellowship (solid state-electronics), IBM Graduate Fellowship in Manufacturing Research, IBM Graduate Fellowship in Computer Networking and Dupont Graduate Fellowships through the Department of Electrical and Computer Engineering; Dupont Fellowship in Chemical Engineering, Phillips Graduate Fellowship, Southeastern Regional and PIA Supplemental Fellowship in the Department of Chemical Engineering; Dean's Fellowships, Microelectronics Center of N.C. and National Consortium for Minorities in Engineering (GEM), all through the College of Engineering; SOHIO Fellowship in the Department of Physics; Gertrude M. Cox Fellowship in the Department of Statistics; Mary Lee and Luther Barnhardt Scholarship in the Department of History; Title IX Fellowship in the Department of Political Science and Public Administration; H. W. Close Fellowship through the College of Textiles.

NATIONAL, REGIONAL AND FOUNDATION FELLOWSHIPS

These awards are made to an individual rather than to the University. Recipients are chosen through competitions expressive of the terms of each award.

Examples of these awards follow:

NSF Graduate Fellowship—The Fellowship Office, National Research Council, 2101 Constitution Avenue, N.W., Washington, D.C. Pre-application packets are available in the Graduate School office, 115 Peele Hall.

American Association of University Women Fellowships—Applications are available through local chapters.

AFRICAN-AMERICAN GRADUATE ASSISTANCE GRANT

The African-American Graduate Assistance Grant (AAGAG) is a grantsmanship program created by North Carolina State University to aid in the support of African-American graduate students in all graduate programs of the University.

The AAGAG program provides stipends on a financial need basis up to \$5,000 for the academic year. Recipients must be full-time students pursuing master's or doctoral degrees or they must have received full admission for their first graduate degree at NCSU.

The Graduate School should be contacted for further information.

ALUMNI ASSOCIATION GRADUATE FELLOWSHIP SUPPLEMENTS

The NCSU Alumni Association each year funds Graduate Fellowship Supplements in an effort to recruit more outstanding graduate students, with the highly competitive award process being coordinated through the Graduate School office. For the 1988-89 academic year twenty-six Graduate Fellowship Supplements were funded; twenty-four of these were awarded across campus and two were awarded to support the management of University Archives. These supplements are awarded on a one-time-only basis as a financial incentive *above and beyond* whatever fellowship or assistantship may be offered.

AMERICAN INDIAN STUDENT LEGISLATIVE GRANT PROGRAM

The General Assembly of North Carolina has provided funds for the American Indian Student Legislative Grant Program for a number of grants to American Indian students interested in pursuing doctoral degrees at NCSU. The fellowships have a maximum value of \$4,000 annually.

To be eligible for a fellowship, interested students must be enrolled full-time and in good standing in a doctoral degree program, meet state residency requirements, have financial need and be an American Indian under the program's definition. This definition states that an eligible individual is one who maintains cultural identification as an American Indian through membership in an Indian tribe recognized by the State of North Carolina or by the federal government or through other tribal affiliation or community recognition.

MINORITY PRESENCE GRANT PROGRAM

Under the Board of Governors general Minority Presence Grant Program, black students may be eligible for special financial assistance if they are residents of North Carolina, enrolled for at least three hours of degree-credit course work and demonstrate financial need.

The Minority Presence Grant Program for Doctoral Study, Law and Veterinary Medicine provides stipends of up to \$4,000 for the academic year, with an option of \$500 in additional support for study in the summer sessions, for black residents of North Carolina who are selected to participate. Recipients must be full-time students pursuing doctoral degrees, law degrees or degrees in veterinary medicine at East Carolina University, North Carolina State University, The University of North Carolina at Chapel Hill or The University of North Carolina at Greensboro.

PATRICIA ROBERTS HARRIS GRADUATE FELLOWSHIPS

Patricia Roberts Harris Graduate Fellowships provide funds for minority or women graduate students who demonstrate financial need and who plan to enroll in programs where such students are traditionally underrepresented nationally. Currently, fellowships are offered in engineering, statistics, physics and entomology. Seven fellowships (with supplements), each in the amount of \$12,000/year, were awarded through the Graduate School in 1989-90. Tuition and fees are also paid. Information pertaining to the fellowships and application forms are available in the Graduate School.

UNIVERSITY RESEARCH ASSISTANTSHIPS FOR MINORITIES

Funds are available on a matching basis with departments for research or teaching assistantships; however, the departmental appointment together with the University Research Assistantship appointment should not amount to less than other research or teaching assistantships in the department. Appropriate duties should be assigned to the student based on the one-quarter time appointment. There are no restrictions with respect to the student's residency status.

The Graduate School should be contacted for further information.

Other Financial Aid

LONG-TERM LOANS

Graduate students who are American citizens or eligible noncitizens may apply to the Financial Aid Office for consideration for long term, low interest loans. To qualify for loans, students must be making satisfactory academic progress and may require demonstration of financial need. The Financial Aid Form is the proper form to be completed for financial aid consideration. Other required forms—Student Data Sheet and Financial Aid Transcript—should be requested along with the FAF from the University's Financial Aid Office. Students are expected to apply for and to accept any available assistantships or fellowships before applying for loans. In the event that the funds available through the Financial Aid Office are insufficient to meet the need of all students who apply and are eligible, priority for these loans will be given to students working on their first undergraduate degree and graduate students will be referred to other programs (see Stafford Student Loans [formerly Guaranteed Student Loans.])

Perkins Loans (Formerly National Direct Student Loans): Graduate students may borrow up to \$18,000 inclusive of any undergraduate Perkins Loans. There is no interest on the loan while the borrower is a full- or half-time student at an institution of higher education. Five months after ceasing to be at least a half-time student, if you are a new borrower, interest begins at five percent per year. The repayment period begins at the same time. A ten-year repayment period is possible for large indebtedness; however, a minimum payment of \$30 per month is required. Interest does not accrue and repayment installments may be postponed during any period not in excess of three years during which the borrower is a member of the Armed Forces of the United States or is a Peace Corps or Vista volunteer. Reduction of obligations to repay may result from teaching in schools with high concentrations of low income families or from teaching handicapped children. New legislation also provides that the Defense Department may repay a portion of your loan if you serve as an enlisted person in certain military occupations after receiving a Perkins Loan.

Institutional Long-Term Loans: These loans are made from University funds. Institutional loans are made and are to be repaid under the same terms as the Perkins Loans except that there are no forgiveness features.

NOTE: Due to a lack of sufficient funds for all students, priority for Perkins Loans and Institutional Loans will be given to undergraduate students.

Stafford Student Loans (Formerly Guaranteed Student Loan Program): This program provides loans from private lenders. Procedures are different in each state. Information for available loans may be obtained in the Financial Aid Office. Interest is at eight percent per year with the Federal government paying the interest during the in-school period. To determine eligibility for a Stafford Student Loan, the financial aid administrator will add the student's Expected Family Contribution to the student's other financial aid. If the total financial aid is less than the cost of education the student is considered to have need and is eligible for a Stafford Student Loan.

Graduate/professional students who are eligible may borrow under the Stafford Student Loan program through College Foundation, Inc. or other lending agencies in the student's state of legal residence, a maximum of \$7,500 per

academic year or the total cost of education less other financial aid (including assistantships and fellowships) whichever is less. A maximum of \$54,750 may be borrowed for graduate/professional study, including undergraduate loans. College Foundation Loans are insured by the North Carolina Education Assistance Authority or the United States Department of Education. Students from other states may obtain information about similar plans from the Financial Aid Office.

PART-TIME JOBS

The College Work Study Program is a federal program designed to provide part-time jobs to students who show need of financial assistance. The same application, the Financial Aid Form, is used to apply for both loans and jobs. Effort is made to assign students to jobs in keeping with their special interests and skills. As is the case with campus-administered loans, priority for these funds is given to undergraduate students pursuing their first undergraduate degree.

Other jobs not based on need are listed at the Financial Aid Office and are open to all students.

SHORT-TERM EMERGENCY LOANS

Loans, usually in amounts of \$100 or less, to meet emergency expenses may be obtained on short notice at the Financial Aid Office. These loans, in that they are designed for short term, emergency use, must be repaid within about 30 days. A loan may not be taken out between semesters or summer sessions.

Military Education and Training

The Reserve Officer Training Corps (ROTC) selects interested University students for enrollment in Army ROTC (AROTC) or in Air Force ROTC (AFROTC) for officer education and training leading toward a commission.

The Army and Air Force ROTC departments educate and train University students, graduate and undergraduate, for a commission in their respective military services. These students must have four full semesters (undergraduate or graduate) remaining at the time they enter the ROTC Program (exceptions for Army ROTC are noted below). Uniforms and books for ROTC are provided. Transfer credit is allowed for previous ROTC course work at other institutions.

Graduate students who will be at NCSU for at least two years may, upon successful completion of a six-weeks' summer leadership training period, be enrolled in the ROTC Program. Entry requirements for either program may also be met by having met any *one* of the following requirements:

1. Completed basic level ROTC courses as an undergraduate.
2. Be an honorably discharged veteran.
3. Have completed military basic training and be a member of an Army/Air Force Reserve or National Guard Unit.

Air Force ROTC offers a Flight Screening Program for selected cadets which is conducted by an Air Force flying school in Texas during the summer at no expense to the student. Students successfully completing ROTC flight screening may be selected for further flight training as an Air Force pilot.

Graduate students enrolled in the junior and senior years of ROTC receive \$100 per month. Scholarships which pay all tuition, fees and costs of required textbooks in addition to the \$100 per month are available on a competitive basis.

Special provisions for veterans are made in Army ROTC whereby they are granted placement credit for their prior service experience and training. Additionally, Army ROTC offers the student several points of entry into the ROTC Program, under a process of granting ROTC placement credit for college courses or other worthwhile experiences that contribute to the requisite skills of a second lieutenant. Army ROTC counselors are available to evaluate the students' prior learning experiences and advise them as to where they can be placed in ROTC. Under the Army's Simultaneous Membership Program, the graduate student may participate in the Army Reserve or National Guard and receive approximately \$84 per month in addition to the \$100 monthly stipend. The National Guard provides up to \$500 tuition costs per year for its members. The student must enlist in the specified component and have completed basic training prior to entry into the program.

Additional information on Army ROTC may be obtained from the Professor of Military Science, Room 154, Reynolds Coliseum (737-2428) and Air Force ROTC from the Professor of Aerospace Studies, Room 145, Reynolds Coliseum (737-2417).

Health Services

The Student Health Service, located in Clark Hall Infirmary, offers health care to students in a campus facility staffed by eight full-time physicians, three Family Nurse Practitioners, a pharmacist, laboratory technicians, registered nurses, health educators and support staff.

During fall and spring semester, the Health Service is open 24 hours a day, seven days a week except during holidays and breaks. Physicians maintain regular office hours Monday through Friday and are on call at other times. (Students must check-in by 4:30 p.m. to see a physician.) A limited-hours outpatient clinic is in operation during summer sessions and semester breaks.

All currently enrolled students are eligible for medical care. The pre-paid health fee covers professional services such as nurse and M.D. visits, laboratory tests, cold medications and health education. There is a nominal charge for x-rays, prescriptions and specialty clinics. Students are responsible for all services received off-campus, *e.g.*, M.D. or hospital.

HEALTH INSURANCE

NCSU strongly encourages each student to have accident and sickness insurance protection, either by their parents' group policy or under the NCSU Student Insurance Plan. The policy offered by the University helps cover the cost of referrals to off-campus specialists or to hospitals for serious illnesses.

For your protection—with the average hospital charge at \$512 per patient day in North Carolina (1988)—do not be uninsured!

International students are required to enroll in a student health insurance program.

A brochure describing the NCSU student plan is mailed to all students in July. Call 737-2563 for additional information.

Housing

ON-CAMPUS HOUSING

The University operates 19 residence halls for single students with a total capacity to accommodate approximately 6,300 students. Eight of the halls are arranged in suites of four or five rooms with a common bathroom. Ten others have rooms which open onto a central corridor with bathrooms at separate intervals. North Hall has private baths in each double room.

Rooms are provided with basic furnishings such as bed, chest of drawers, desk, chair and waste basket for each double or single room occupant. An optional linen rental service is available through the University Laundry and Dry Cleaning Service.

The 1989-90 rental fee for a main campus residence hall double room is \$650 per semester per student and may increase in future years. Room rents in North Hall and South Hall are higher. With the exception of Watauga Hall (graduate and upper class residence hall), new freshmen and continuing residents have priority for a room assignment over new graduate students. Students who are unable to secure on-campus housing before school begins may contact the Housing Assignments Office, 1112 Student Services Center, on or after September concerning the availability of housing on campus at that time.

OFF-CAMPUS HOUSING

The Housing Assignments Office also maintains a self-help facility which makes available listings of off-campus housing accommodations sent to them by private landlords; however, specific arrangements for this housing must be contracted for by those individuals concerned. The listings are not mailed as they change frequently and most landlords and tenants prefer to complete the rental transaction in person rather than by telephone or mail. The Housing Assignments Office is open from 8:00 a.m. until 5:00 p.m., Monday through Friday only.

EDWARD S. KING VILLAGE

The University also maintains 295 apartments for married couples, married couples with children, graduate students, single married students with no children and non-traditional undergraduate students. E. S. King Village includes studios, one-bedroom and two-bedroom apartments. The monthly rental rates for the 1989-90 year are \$220 (includes gas) for studios, \$220 for one-bedroom apartments and \$245 for the two-bedroom apartments. All apartments have built-in dresser drawers, closets, a stove and a refrigerator. Interested students should write to E. S. King Village, P Building, North Carolina State University, Raleigh, NC 27607 for housing applications and information or telephone (919) 737-2430.

Additional Information

If additional information is needed, contact the Graduate School, 103 Peele Hall, P. O. Box 7102, North Carolina State University, Raleigh, N.C. 27695-7102 (telephone 919/737-2872).

GRADUATE PROGRAMS

The Graduate School offers programs of study leading to the master's degree in 77 fields and the doctorate in 48. Each student's program is planned with an advisory committee of graduate faculty members to provide the opportunity for gaining advanced knowledge in the particular field of study. Graduate education is the final stage in the development of intellectual independence. It is different from undergraduate education in that the student is encouraged to establish premises, to hypothesize and to defend both the procedure and the conclusions of independent investigation. The burden of proof for the verifiability of knowledge rests on the student, not on the faculty member. Emphasis is placed upon the student's scholarly development through formal course work, seminars, research and independent investigation.

Graduate students are expected to familiarize themselves with the requirements for the degrees for which they are candidates and are held responsible for the fulfillment of these requirements.

The Graduate School offers courses of study in the following fields:

Aerospace Engineering—M.S., Ph.D.

Agricultural Economics—M.S.

Agriculture—Master of

Animal Science—M.S., Ph.D.

Applied Mathematics—M.S., Ph.D.

Architecture—Master of

Archival Management—M.A.

Biochemistry—M.S., Ph.D.

Biological and Agricultural Engineering—Master of, M.S., Ph.D.

Biomathematics—Master of, M.S., Ph.D.

Botany—M.S., Ph.D.

Chemical Engineering—Master of, M.S., Ph.D.

Chemistry—Master of, M.S., Ph.D.

Civil Engineering—Master of, M.S., Ph.D.

Computer Engineering—Master of, M.S., Ph.D.

Crop Science—M.S., Ph.D.

Ecology—M.S.

Economics—Master of, M.A., Ph.D.

Education—(Master of Education offered in fields listed below)

Adult and Community College Education—M.S., Ed.D.

Agricultural Education—M.S.

Curriculum and Instruction—M.S., Ed.D.

Educational Administration and Supervision—M.S., Ed.D.

Guidance and Personnel Services—M.S., Ed.D.

Higher Education Administration—Master of, M.S., Ed.D.

Industrial Arts Education—M.S., Ed.D.

Mathematics Education—M.S., Ph.D.

Middle Grades Education—M.S.

Occupational Education—M.S., Ed.D.

Science Education—M.S., Ph.D.

Special Education—M.S.

Vocational Industrial Education—M.S.

Electrical Engineering—Master of, M.S., Ph.D.
*Engineering—Master of
English—M.A.
Entomology—M.S., Ph.D.
Fiber and Polymer Science—Ph.D.
Food Science—M.S., Ph.D.
Forestry—Master of, M.S., Ph.D.
Genetics—M.S., Ph.D.
History—M.A.
Horticultural Science—M.S., Ph.D.
Industrial Engineering—Master of, M.S., Ph.D.
Integrated Manufacturing Systems Engineering—Master of
Landscape Architecture—Master of
Liberal Studies—M.A.
Life Sciences—Master of
Management—M.S.
Marine, Earth and Atmospheric Sciences—M.S., Ph.D.
Materials Science and Engineering—Master of, M.S., Ph.D.
Mathematics—M.S., Ph.D.
Mechanical Engineering—Master of, M.S., Ph.D.
Microbiology—M.S., Ph.D.
Nuclear Engineering—Master of, M.S., Ph.D.
Nutrition—M.S., Ph.D.
Operations Research—M.S., Ph.D.
Physics—M.S., Ph.D.
Physiology—M.S., Ph.D.
Plant Pathology—M.S., Ph.D.
Political Science—M.A.
Poultry Science—M.S.
Product Design—Master of
Psychology—M.S., Ph.D.
Public Affairs—Master of
Recreation Resources Administration—Master of, M.S.
Rural Sociology—M.S.
Sociology—Master of, Ph.D.
Soil Science—M.S., Ph.D.
Statistics—Master of, M.S., Ph.D.
Technical Communication—M.S.
Technology for International Development—Master of
Textile Chemistry—M.S.
Textile Engineering and Science—Master of, M.S.
Textile Management and Technology—Master of, M.S.
Toxicology—Master of, M.S., Ph.D.
Veterinary Medical Sciences—M.S., Ph.D.
Wildlife Biology—Master of, M.S.
Wood and Paper Science—Master of, M.S., Ph.D.
Zoology—M.S., Ph.D.

Master's Degrees

The Graduate School offers programs of study leading to the Master of Science degree, the Master of Arts degree and the Master's degree in certain designated fields.

MASTER OF SCIENCE AND MASTER OF ARTS

For all Master of Science and Master of Arts degrees, the programs are planned with the objective of making possible a reasonable, comprehensive mastery of the subject matter in the chosen field. Training and experience in research are provided to familiarize the student with the methods, ideals and goals of independent investigation.

ADVISORY COMMITTEE AND PLAN OF GRADUATE WORK

The advisory committee is composed of at least three members of the Graduate Faculty, one of whom is designated as the chair and one of whom represents the supporting area. This committee is appointed by the Graduate Dean upon the recommendation of the head of the major department.

The student's program of study is planned so as to provide a comprehensive view of the major field of interest and to provide training in research in this field and related areas of knowledge. As great a latitude is permitted in the selection of courses as is compatible with a well-defined major and supporting courses. In general, it is expected that approximately two-thirds of the course work will be in the major and one-third in supporting courses. Since there are many possible combinations of course work, a specific Plan of Graduate Work is developed by the advisory committee with the student. The program of course work to be followed by the student and the thesis problem selected must be approved by the student's advisory committee, the head of the department and the Graduate School. The Plan of Graduate Work should be submitted to the Graduate School for approval prior to completion of one-half of the program.

CO-MAJOR

Students may co-major at the master's level with the approval of both departments and appropriate representation on the advisory committee. Co-majors must meet all requirements for majors in both departments. One degree is awarded and the co-major is noted on the transcript. A co-major must involve degree programs with similar requirements. Co-majors are not permitted between thesis and non-thesis degree programs or between Doctor of Philosophy and Doctor of Education degree programs. Enrolled co-majors will be classified in only one program for record purposes.

RESIDENCE

Students engaged in a course of study leading to the Master of Science or Master of Arts degree are required to be in residence, pursuing graduate work, for a minimum of one full academic year or its equivalent.

CREDITS

A minimum of 30 semester credits is required for the Master of Science or Master of Arts; however, the number of credit hours included in a Plan of Graduate Work often exceeds this minimum. At least 20 semester hours must come from 500- and 600-level courses. The program may include no more than six hours of research and no more than two hours of departmental seminar, unless the total program exceeds 30 hours. Courses at the 400-level counted toward the minimal 30-hour requirement may not come from the major field.

CREDIT FROM OUTSIDE SOURCES

Transfer Credit. No more than six of the required academic credits will be accepted from other institutions. A graduate course may be considered for transfer to a master's program provided it has been completed in a graduate or post-baccalaureate classification at an accredited graduate school with a grade of "B" or better. Transfer credit may not be used to fill the 20-hour 500- and 600-level course requirement in master's programs. Credit accepted by extension reduces the amount of credit that may be transferred from other institutions.

Transfer of Undergraduate Credit. No graduate credit will be allowed for excess credits completed in an undergraduate classification at another institution.

Correspondence Courses and Extension Courses. No graduate credit will be allowed for correspondence courses or for courses completed by extension at universities other than NCSU.

Credit by Extension. A maximum of six semester credits taken prior to admission to a graduate program and earned through NCSU extension study may be applied toward degree requirements provided the courses are graduate level and are taught by members of the NCSU Graduate Faculty. If a student has been admitted to the Graduate School and an approved Plan of Graduate Work has been submitted, six additional semester credits may be obtained in off-campus NCSU graduate courses to apply toward the minimal credit hour requirement for the degree. Credit accepted by extension reduces the amount of credit which may be transferred from other institutions.

GRADING AND ACADEMIC STANDING

Performance in lecture courses is evaluated as "A" (Excellent), "B" (Good), "C" (Passing), "D" or "NC" (No credit). In order to receive graduate degree credit, a grade of "C" or higher is required. All grades on courses taken for graduate credit as an undergraduate at NCSU and all grades on courses taken in a graduate classification at NCSU in courses numbered 400 and above are included in the graduate grade point average. Courses at the 300 level and below are not considered for graduate credit and grades earned on them do not enter the grade point average.

Performance in research, seminar and special problems courses is evaluated as either "S" (Satisfactory) or "U" (Unsatisfactory), and these grades are not used in computing the grade point average. However, a student who receives a "U" on any course will not receive credit for that course and may be required to repeat it.

The "Master Listing of Approved Graduate Courses" identifies the approved

grading (A,B,C,D,NC or S,U) for each 500- and 600-level course. Generally, courses numbered through the 590 series and the 690 series will receive "S" or "U" grading. Other course numbers will carry A,B,C,D,NC grading. Any deviation from the approved grading for a particular course must be requested by the department and approved by the Academic College/School Dean and the Graduate Dean prior to teaching the course. Also included in the GPA calculation and the determination of academic standing are all 400-600-level credits earned by a student in a PBS classification at NCSU within six years of the date of enrollment as a graduate student. (See the Post-baccalaureate Studies section for restrictions concerning Post-baccalaureate Studies courses.)

At the discretion of the instructor, students may be given an "IN" (Incomplete) grade for work not completed because of a serious interruption in their work not caused by their own negligence. An "IN" must not be used, however, as a substitute for an NC when the student's performance in the course is deserving of No Credit. An "IN" is only appropriate when the student's record in the course is such that the successful completion of particular assignments, projects, or tests missed as a result of a documented serious event would enable that student to pass the course. Only work missed may be averaged into the grades already recorded for that student. A student who receives an "IN" must complete the unfinished work to have the Incomplete converted to a final grade by the end of the next semester in which the student is enrolled provided that this period is not longer than 12 months from the end of the semester or summer session in which the Incomplete was received; otherwise, the "IN" will be automatically converted to "NC" or "U," in accord with the grading approved for the particular course. All grades of "IN" must be cleared prior to graduation. Students must not register again for any courses in which they have "IN" grades; such registration does not remove "IN" grades, and the completion of the course on the second occasion will automatically result in an NC for the incompleeted course.

Except in the case of Interinstitutional Registration (see p. 18), grades on courses transferred from another institution will not be included in computing the grade point average.

Graduate students are given a notice of academic warning if they have accumulated less than nine hours at the 400-level or above and have less than a 3.0 ("B" average). Graduate students are placed on academic probation if they accumulate nine or more but less than eighteen credit hours at the 400-level or above and have a grade point average of less than 3.0 ("B" average). A student's graduate study is terminated if eighteen or more credit hours at the 400-level or above are accumulated with a grade point average of less than 3.0 ("B" average). In the case of program termination, no further registration in a graduate classification will be permitted. Under extenuating circumstances the student will be reinstated upon the written recommendation of the department and approval by the Graduate Dean. (Effective Fall 1978 for all graduate students.) Departments have the prerogative of recommending the termination of a student's graduate admission at any time.

Students who are eligible to attend the first summer session are eligible to attend either or both summer sessions. For example, students who receive a notice of "Graduate Admission Terminated" at the end of the first summer session may register for the second summer session unless the major department recommends otherwise.

A graduate student must be in good academic standing ("B" or better average) to be eligible for appointment to an assistantship, fellowship or traineeship and must be registered in each semester in which the appointment is in effect.

LANGUAGE REQUIREMENTS

A reading knowledge of one modern foreign language (Germanic, Romance or Slavic) is required by some programs for the Master of Arts and the Master of Science degrees. Students should contact the major department for specific language requirements.

Proficiency can be demonstrated in one of two ways:

1. By passing a traditional reading knowledge examination, which can be requested by the student at any time.
2. By passing the final examination in a course especially designed for graduate students who have no previous knowledge of a foreign language or who wish to refresh their knowledge of a language. The Department of Foreign Languages and Literatures offers such courses, normally in the fall, for each of the three major foreign languages: French (FLF 401), German (FLG 401) and Spanish (FLS 401). These courses concentrate exclusively on teaching students to understand the written word and do not provide instruction or testing in speaking and original composition. Failure to pass the course carries with it no penalty other than the fact that the student's language requirement will remain unfulfilled. These courses are neither counted for credit nor used in computing the grade point average.

THESIS

Theses prepared by candidates for the Master of Science or Master of Arts degree must represent an original investigation into a subject which has been approved by the student's advisory committee and the head of the major department. Three copies of the thesis in final form as approved by the advisory committee, each signed by the members of the advisory committee, must be submitted to the Graduate School by a specific deadline in the semester or summer session in which the degree is to be conferred. Detailed information on form and organization of the thesis is presented in the University's *Guide for the Preparation of Theses*, which is available in the Graduate School office.

COMPREHENSIVE WRITTEN EXAMINATIONS

Written examinations covering the subject matter of the major and supporting fields may be required of the candidate. When required, such examinations must be successfully completed prior to requesting the comprehensive oral examination. Information concerning written examination schedules should be obtained from the student's major department.

COMPREHENSIVE ORAL EXAMINATIONS

A candidate for the Master of Science or Master of Arts degree must pass a comprehensive oral examination to demonstrate to the advisory committee that he or she possesses a reasonable mastery of the subject matter of the major and supporting fields and that this knowledge can be used with promptness and

accuracy. This examination may not be held until all other requirements, except completion of the course work in current registration during the final semester, are satisfied. Application for the examination must be filed with the Dean of the Graduate School by the chair of the advisory committee at least two weeks prior to the date on which the examination is to be held and, in the case of thesis degrees, after the thesis is complete except for such revisions which may be necessary as a result of the final examination.

A unanimous vote of approval by the advisory committee is required for passing the oral examination. Approval of the examination may be conditioned, however, upon the completion of additional work to the satisfaction of the advisory committee. A formal reexamination will not be required in this case. Failure of a student to pass the oral examination terminates the student's graduate work at this institution unless otherwise unanimously recommended by the advisory committee. Only one reexamination will be permitted. All committee actions may be appealed by written application to the Graduate Dean.

Oral examinations for master's degree candidates are open to the graduate faculty by right and to the University community by unanimous consent of the advisory committee and the student being examined. Discussions and decisions regarding the student's performance are private to the advisory committee.

TIME LIMIT

All requirements for the master's degree must be completed within six calendar years, beginning with the date the student commences courses carrying graduate credit applicable to the degree program, unless a more restrictive time limit has been established by the academic college/school.

MASTER'S DEGREE IN A DESIGNATED FIELD

The University offers a number of master's degree programs in designated fields. The degree offerings are listed below. These programs vary in requirements and persons having an interest in these programs are advised to contact the major department for further information including specific prerequisites and degree requirements. General Graduate School policies as stated on page 35 through 39 apply to these degree programs with the exception of references to the master's thesis.

MASTER OF AGRICULTURE DEGREE AND MASTER OF LIFE SCIENCES DEGREE

The requirements for either of these degrees are as follows:

1. A total of 36 semester hours is required.
2. A minimum of four semester hours in special problems is required; not more than six semester hours in special problems will be allowed. This work replaces the research thesis requirement for the Master of Science or Master of Arts degrees.
3. A minimum of 20 credit hours of 500- or 600-level course work is required.

In all other respects, the requirements for the Master of Agriculture or the Master of Life Sciences degree are the same as those for the Master of Science and Master of Arts degrees.

Summary of Procedures for Master's Degrees

1. Letter of inquiry from prospective student to Graduate School or department head.
2. Mailing of proper forms to student.
3. Receipt of application materials and required fee.
4. Review of application materials by department or program.
5. Department forwards recommendation regarding applicant's admissibility to Graduate Dean.
6. The department's recommendation is reviewed and the student is notified of the action taken on the request for admission.
7. Student arrives, reports to the department, is assigned an adviser and makes out a roster of courses in consultation with the departmental adviser.
8. Advisory committee of three or more graduate faculty members, one of whom is designated as the chair and one of whom represents the supporting field, appointed by the Graduate Dean upon the recommendation of the department head.
9. Plan of Work prepared by the advisory committee with the student and submitted in quadruplicate to the department head and the Graduate School for approval prior to completion of one-half of the proposed program.
10. Three copies of the approved Plan of Work returned to the department. One copy is kept in department files, one is returned to the committee chair and one is given to the student.
11. Student passes language examination (if required by the major department).
12. Written examination in the major and/or supporting fields may be required of the candidate. If required, written examinations must be successfully completed prior to requesting the comprehensive oral examination.
13. A copy of a preliminary draft of the thesis is submitted to the chair of the student's advisory committee for review. (Thesis degrees only).
14. The diploma order request form must be filed with the Graduate School by the end of the third week of the semester or summer session of anticipated graduation. Failure to submit the form by this date may result in the student's not receiving the diploma at graduation.
15. At least two weeks prior to the final oral examination, the chair of the student's advisory committee submits the thesis to advisory committee members for review. (Thesis degrees only).
16. The final oral examination may be scheduled when all other requirements except completion of the course work for the final semester are satisfied and, in the case of thesis degrees, after the thesis is complete except for such revisions as may be necessary as a result of the examination. Permission for the candidate to take the final oral examination is requested of the Graduate School at least two weeks before the examination. Specific deadline dates for non-thesis master's candidates appear in The Calendar.
17. The Graduate Dean schedules the examination and notifies the student and advisory committee of the time and place. The report on the final examination should be filed with the Graduate School as soon as the examination has been completed.
18. Three copies of the thesis signed by each member of the student's advisory committee must be submitted to the Graduate School by a specific deadline

in the semester or summer session in which the degree is to be conferred. Specific deadline dates appear in The Calendar.

19. The thesis is reviewed by the Graduate School to insure that the format conforms with the specifications prescribed in the *Guide for the Preparation of Theses*. (Thesis degrees only).
20. All course work scheduled in a graduate degree classification must be completed prior to graduation.
21. A grade point average of at least 3.0 for the degree requirements as well as on overall course work is required for graduation.
22. All degree requirements must be completed within six calendar years, beginning with the date the student commences courses carrying graduate credit applicable to the degree program, unless a more restrictive time limit has been established by the academic college/school.

Doctor of Philosophy and Doctor of Education Degrees

The doctorate symbolizes the ability of the recipient to undertake original research and scholarly work at the highest levels without supervision. The degree is therefore not granted simply upon completion of a stated amount of course work but rather upon demonstration by the student of a comprehensive knowledge and high attainment in scholarship in a specialized field of study. The student must demonstrate this ability by writing a dissertation reporting the results of an original investigation and by passing a series of comprehensive examinations in the field of specialization and related areas of knowledge.

ADVISORY COMMITTEE AND PLAN OF GRADUATE WORK

An advisory committee of at least four graduate faculty members, one of whom will be designated as chair, will be appointed by the Dean of the Graduate School upon the recommendation of the head of the major department. The committee, which must include at least one representative of the minor field, will, with the student, prepare a Plan of Graduate Work which must be approved by the department head and the Graduate School. In addition to the course work to be undertaken, the subject of the student's dissertation must appear on the plan; and any subsequent changes in committee or subject or in the overall plan must be submitted for approval.

The program of work must be unified, and all constituent parts must contribute to an organized program of study and research. Courses must be selected from groups embracing one principal subject of concentration, the major, and from a cognate field, the minor. Normally, a student will select the minor work from a single discipline or field which, in the judgment of the advisory committee, provides relevant support to the major field. However, when the advisory committee finds that the needs of the student will best be served by work in an interdisciplinary minor, it has the alternative of developing a special program in lieu of the usual minor.

CO-MAJOR

Students may co-major at the doctoral level with the approval of both departments and appropriate representation on the advisory committee. Co-majors must meet all requirements for majors in both departments. One degree is

awarded and the co-major is noted on the transcript. A co-major must involve degree programs with similar requirements. Co-majors are not permitted between thesis and non-thesis degree programs or between Doctor of Philosophy and Doctor of Education degree programs. Enrolled co-majors will be classified in only one program for record purposes.

RESIDENCE REQUIREMENT

For the Doctor of Philosophy and the Doctor of Education degrees, the student is expected to be registered for graduate work at an accredited graduate school for at least six semesters beyond the baccalaureate degree.

The basic University residence requirements are defined below. However, academic colleges/schools have the prerogative of establishing more restrictive requirements within the respective colleges/schools. (The College of Education and Psychology requires a minimum of one academic year of full-time resident study).

At least two residence credits, as defined below, must be secured in continuous residence (registration in consecutive semesters) as a graduate student at the University. Failure to take work during the summer does not break continuity; however, summer work may be used in partial fulfillment of this requirement.

Residence credit is determined by the number of semester hours of graduate work carried during a given term. During a regular semester, residence credit is calculated in the following manner:

<i>Semester Credits (Hours)</i>	<i>Residence Credits</i>
9 or more	1
6-8	2/3
less than 6 (including registration for "Thesis Preparation")	1/3

The residence credit for a six-week summer term is equal to one-half of the corresponding amount for a regular semester. For example, six semester hours carried during a summer session will earn one-third of a residence credit; less than six credit hours will earn one-sixth of a residence credit.

GRADING AND ACADEMIC STANDING

The grading system and grade requirements for all doctoral programs are the same as those for master's degree programs, as described on pages 36-37.

LANGUAGE REQUIREMENTS

A reading knowledge of at least one modern foreign language is required by some departments for the Doctor of Philosophy degree. Doctoral students should contact the major department for specific language requirements. For the Doctor of Education degree, the decision as to whether or not there will be a language requirement is left to the student's advisory committee.

Students who choose to demonstrate a reading knowledge of a language may select from any of the Romance, Germanic or Slavic languages (or any combination in those programs requiring two languages). The Department of Foreign Languages and Literatures offers courses in French, German and Spanish especially designed for graduate students who have no previous knowledge of a foreign language or who wish to refresh their knowledge of a language. These

courses concentrate exclusively on teaching students to understand the written word and do not provide instruction or testing in speaking and original composition. A passing grade on the final examination in one of these courses is sufficient evidence of a reading knowledge of the language.

To demonstrate comprehension in depth of one language, a student must not only prove that one possesses a reading knowledge of the language but also that he or she is proficient in the oral and compositional elements of that language. Students desiring to master one language in depth should consult the head of the Department of Foreign Languages and Literatures concerning the specific courses which will be necessary to achieve this comprehension; specific arrangements will depend upon the student's background in the language.

Students whose native language is other than English may use English as one of the languages when two are required for the Doctor of Philosophy degree. When English is submitted in partial fulfillment of the dual language requirement, the native language may not be used as the other language.

When only one language is required in the student's program, certification for that language must occur on this campus.

PRELIMINARY COMPREHENSIVE EXAMINATIONS

After completing the language requirement but not earlier than the end of the second year of graduate study and not later than one semester (four months) before the final oral examination, each doctoral student is required to take the preliminary comprehensive examinations. The examinations consist of two parts: written examinations and an oral examination. Requirements for written examinations in the minor field are left to the discretion of the department in which the student is minoring.

The written portion may be conducted in one of two ways. In the first, each member of the advisory committee prepares a set of questions for the student's response, and answers to each set are returned to the appropriate member for grading. This procedure is used by departments which have a relatively small number of doctoral students.

Many of the larger departments have developed departmental written examinations to be used for all students. These examinations are given several times during the year, and scheduled dates are announced well in advance. Where written departmental examinations of this kind are used, the student will be expected to make arrangements to schedule these examinations.

Regardless of the method employed, the questions involved may cover any phase of the course work taken by the student during graduate study or any subject logically related to an understanding of the subject matter in the major and minor areas of study. The questions are designed to measure the student's mastery of the subject matter and the adequacy of preparation for research. Failure to pass the written preliminary examinations terminates the student's work at this institution, subject to departmental and/or college/school policies with respect to reexamination.

Upon satisfactory completion of the written portion of the preliminary examinations and after completion of all course work relevant to the examination, authorization for the preliminary oral examination is requested from the Graduate School. This examination is conducted by the student's advisory committee and a representative from the Graduate School and is open to all graduate faculty

members. The student and the examining committee will be notified by the Graduate School of the arranged time and place. The oral examination is designed to test the student's ability to relate factual knowledge to specific circumstances, to use this knowledge with accuracy and promptness and to demonstrate a comprehensive understanding of the field of specialization and related areas.

A unanimous vote of approval by the members of the advisory committee is required for the student to pass the preliminary oral examination. Approval may be conditioned, however, on the successful completion of additional work in some particular field(s). All committee actions may be appealed by written application to the Graduate Dean.

Failure to pass the preliminary oral examination terminates the student's work at this institution unless the examining committee recommends a reexamination. No reexamination may be given until at least one full semester has elapsed, and only one reexamination is permitted.

CANDIDACY

A doctoral student is admitted to candidacy upon passing the preliminary examinations without conditions or after fulfilling any conditions specified by the advisory committee.

FINAL ORAL EXAMINATION

The final oral examination is scheduled after the dissertation is complete except for such revisions as may be necessary as a result of the examination, but not earlier than one semester or its equivalent after admission to candidacy and not before all required course work has been completed or is currently in progress. The examination consists of the candidate's defense of the methodology used and the conclusions reached in the research, as reported in the dissertation. It is conducted by an examining committee, which consists of the student's advisory committee and a Graduate School representative. This examination is open to the University community.

A unanimous vote of approval of the advisory committee is required for passing the final oral examination. Approval may be conditioned, however, on the student's meeting specific requirements prescribed by the student's advisory committee. Failure of a student to pass the examination terminates one's work at this institution unless the advisory committee recommends a reexamination. No reexamination may be given until one full semester has elapsed and only one reexamination is permitted.

THE DISSERTATION

The doctoral dissertation presents the results of the student's original investigation in the field of major interest. It must represent a contribution to knowledge, be adequately supported by data and be written in a manner consistent with the highest standards of scholarship. Publication is expected.

The dissertation will be reviewed by all members of the advisory committee and must receive their approval prior to submission to the Graduate School. Three copies of the document signed by all members of the student's advisory committee must be submitted to the Graduate School by a specific deadline in the semester or summer session in which the degree is to be conferred. Prior to final

approval, the dissertation will be reviewed by the Graduate School to insure that the format conforms to the specifications prescribed in the *Guide for the Preparation of Theses*. Detailed information on form and organization of the dissertation is presented in the University's *Guide for the Preparation of Theses* which is available in the Graduate School office.

The University has a requirement that all doctoral dissertations be micro-filmed by University Microfilms International, of Ann Arbor, Michigan, which includes publication of the abstract in *Dissertation Abstracts International*. The student is required to pay for the microfilming service. (See "Special Registration and Fees" under "Tuition and Fees.")

TIME LIMIT

Doctoral students are allowed a maximum of six calendar years from admission to the doctoral program to attain candidacy for the degree and a maximum of ten calendar years to complete all degree requirements. Academic colleges/schools or departments may have more restrictive requirements than the above stated University policy. All students admitted to doctoral programs effective Fall 1979 are subject to the above policy. Time limits for students admitted to doctoral programs prior to Fall 1979 but who were not admitted to candidacy as of Fall 1979 and who do not meet the above policy will be considered on an individual basis. Doctoral students admitted to candidacy prior to the 1979 fall semester are subject to the previous policy which allowed seven calendar years from admission to candidacy to completion of all degree requirements.

Summary of Procedures for the Doctor of Philosophy and Doctor of Education Degrees

1. Letter of inquiry from prospective student to Graduate School or department head.
2. Mailing of proper forms to student.
3. Receipt of application materials and required fee.
4. Review of application materials by department or program.
5. Department forwards recommendation regarding applicant's admissibility to Graduate Dean
6. The department's recommendation is reviewed and the student is notified of the action taken on the request for admission.
7. Student arrives, reports to the department, is assigned an adviser and makes out a roster of courses in consultation with the departmental adviser.
8. Advisory committee of at least four graduate faculty members, one of whom is designated as the chair and one of whom represents the minor field, appointed by the Graduate Dean upon the recommendation of the department head.
9. A dissertation subject is selected and an outline of the proposed research submitted to the student's advisory committee and the department head for review and approval.
10. Plan of Work prepared by the advisory committee with the student and submitted in quadruplicate to the department head and the Graduate School for approval as soon as feasible after completion of 12 hours of course work.

11. Three copies of the approved Plan of Work returned to the department. One copy is kept in department files, one is returned to the committee chair and one is given to the student.
12. Student passes language examination(s). (See page 42.)
13. Written examinations in the major and minor fields are scheduled no earlier than the end of the second year of graduate study and not later than one semester before the final oral examination. The results of these examinations will be reported to the Graduate School.
14. When all written examinations have been completed satisfactorily, the chairman requests the scheduling of the preliminary oral examination at least two weeks prior to the suggested date. Upon approval of the request, a graduate faculty member is selected to represent the Graduate School at the examination, and the student and examining committee are notified of the time and place. The report of the examination is sent to the Graduate School and if the examination has been passed without conditions, the student is admitted to candidacy.
15. A copy of the preliminary draft of the dissertation is submitted to the chair of the student's advisory committee for review.
16. The diploma order request form must be filed with the Graduate School by the end of the third week of the semester or summer session of anticipated graduation. Failure to submit the form by this date may result in the student's not receiving the diploma at graduation.
17. At least two weeks prior to the final oral examination, the chair of the student's advisory committee submits the dissertation to advisory committee members for review.
18. One semester or its equivalent after admission to candidacy or later, and after the dissertation is complete except for such revisions as may be necessary as a result of the final examination, permission for the candidate to take the final oral examination is requested of the Graduate School by the chair of the candidate's advisory committee. Requests should be filed at least two weeks before the date of the examination. Upon approval of the request, the student and the examining committee, including a Graduate School representative, are notified of the time and place of the examination. The Graduate School Representative receives a copy of the dissertation at least one week prior to the examination.
19. Three copies of the dissertation signed by each member of the student's advisory committee and five copies of the abstract must be submitted to the Graduate School by a specific deadline in the semester or summer session in which the degree is to be conferred. Specific deadline dates appear in The Calendar. One copy each of the University Microfilms Agreement and the Survey of Earned Doctorate forms must be submitted with the dissertation.
20. The dissertation is reviewed by the Graduate School to insure that the format conforms with the specifications prescribed in the *Guide for the Preparation of Theses*.
21. All course work scheduled in a graduate degree classification must be completed prior to graduation.
22. A grade point average of at least 3.0 is required for graduation.
23. The statute of limitations for completion of degree requirements is described on page 45.

The D. H. Hill Library

The NCSU Libraries consist of the D. H. Hill Library and five branch libraries. They contain more than 1.2 million volumes of books and bound journals, 800,000 federal government publications, and more than 2.5 million microforms. The collections are particularly strong in the biological and physical sciences, engineering, agriculture, forestry, textiles and architecture, with the arts, humanities and social sciences also well represented. The Libraries regularly receive more than 19,300 serials. Five special libraries—the Burlington Textiles Library in Nelson Hall, the Harry B. Lyons Design Library in Brooks Hall, the College of Forest Resources Library in Biltmore Hall, the Veterinary Medical Library in the Veterinary Medical Building and the Curriculum Materials Center in Poe Hall—serve the special needs of their respective school and colleges.

The NCSU Libraries have been a depository for U. S. federal documents since 1924 and receive over 94 percent of these publications. The Libraries also receive microfiche research reports published by the Department of Energy, the National Aeronautical and Space Administration (NASA), the Educational Resources Information Center (ERIC) and the National Technical Information Service (NTIS). The library is an official U.S. Patent depository and has a complete collection of U.S. patents on microfilm from 1790 to date.

The BIS on-line, computer-based author, title and subject catalog permits rapid identification of monographs and serials in the collections of the NCSU Libraries as well as those of Duke University and UNC-Chapel Hill. This resource sharing greatly enhances the research capabilities of the NCSU Libraries. This is made possible through the Libraries' participation in the Triangle Research Libraries Network (TRLN). An automated circulation system introduced in the 1989-90 year provides quick, easy check-out of books by borrowers.

On-line computer-based literature searches are offered by the library for a number of data bases, ERIC, BIOSIS, AGRICOLA (Bibliography of Agriculture) and Psychological Abstracts. Only direct costs are charged to the user. In addition, a number of bibliographic data bases are provided on CS-ROM and laser disk formats for computerized literature searching by users at no charge.

As a further aid to graduate and faculty research, the Libraries provides interlibrary loan services to obtain material from other research libraries. Direct borrowing privileges are available with UNC-Chapel Hill and Duke University.

Among the many services offered by the library are orientation tours for faculty and graduate students and also lectures on library use to all new students. Comprehensive reference service is available almost all the hours the library is open. A variety of microtext readers and printers in the library and an extensive microfilm collection provide access to much important research material. The Media Center is equipped with audio and video equipment for group and individual viewing and listening. The Library has a growing collection of video and audio cassettes for individual and class use.

Institutes

RESEARCH TRIANGLE

The unique "Research Triangle" in North Carolina has captured national and international attention. It is a complex of three major research universities and a research park. Because of this wealth of educational and research opportunities, the Triangle area contains the highest total of Ph.D. scientists and engineers on a per capita basis in the nation. The Triangle Universities—NCSU, the University of North Carolina at Chapel Hill and Duke University—have a subsidiary campus in the Park—the Research Triangle Institute—which has an annual research revenue of approximately \$60 million.

The Park, which announced its first tenant in 1965, now has over 57 public and industrial research organizations situated on 6,650 acres of land. Over 25,000 people work in the Research Triangle Park. Organizations in the Park include the permanent headquarters of the National Institute of Environmental Health Sciences, the Environmental Protection Agency and the National Center for the Humanities as well as facilities of private companies like IBM, Glaxco and Burroughs Wellcome. Two major new research complexes for microelectronics and biotechnology were recently built in the Park and the North Carolina

Supercomputer building is under construction. Faculty and graduate students from the universities work closely with many of the companies and agencies in the Park and scientists from the Park frequently hold adjunct appointments in one or another of the Triangle Universities.

INSTITUTE OF STATISTICS

The Institute of Statistics is composed of two sections, one at Raleigh and the other at Chapel Hill. At North Carolina State University, the Institute provides statistical consulting to all branches of the institution, sponsors research in statistical theory and methodology and coordinates the teaching of statistics at the undergraduate and graduate levels. The instructional and other academic functions are performed by the Department of Statistics, which forms a part of the Institute.

WATER RESOURCES RESEARCH INSTITUTE

The Water Resources Research Institute is a unit of the University of North Carolina System and is located on the campus of North Carolina State University. The deans of the College of Engineering and College of Agriculture and Life Sciences, the Vice Chancellor for Research at North Carolina State University and two faculty members from the University of North Carolina at Chapel Hill serve as a board of directors. The Institute was established to promote a multidisciplinary attack on water problems, to develop and support research in response to the needs of North Carolina, to encourage strengthened educational programs in water resources, to coordinate research and educational programs dealing with water resources and to provide a link between the state and federal water resources agencies and related interests in the University.

Research and educational activities are conducted through established departments and schools of the University System. All senior colleges and universities of North Carolina are eligible to participate in the Institute's research program. Basic support for the Institute's program is provided by the Office of Water Research and Technology, U.S. Department of the Interior, under the Water Research and Development Act of 1978 and appropriations from the State of North Carolina.

The Institute has sponsored a graduate minor in water resources which offers a strong water resources program with the major in any of the basic disciplines contributing to water resources planning, conservation, development and management. This capitalizes on the combined training resources of the Raleigh and Chapel Hill campuses of the University System and offers these in an organized way to graduate students seeking interdisciplinary training in this field. Additional information concerning the program is presented elsewhere in this catalog.

The Institute sponsors research and educational symposia and seminars, encourages the development of specialized training opportunities and provides a means for the continuing evaluation and strengthening of the University System's total water resources program.

Special Laboratories and Facilities

ACADEMIC COMPUTING FACILITIES

Centralized computing facilities for the University are located in the Hillsborough Building and in other campus buildings. The Computing Center provides computing services as well as networking services via the University's Computer Communications System which links many computing systems on campus, including the on-line Library catalog. Access to computing services at other centers and universities and other network services are provided using the Internet and Bitnet. The University is one of the participating institutions in the North Carolina Supercomputer Center, and high bandwidth communications are provided to the CRAY Y-MP at that Center.

The Computing Center facility includes an IBM 3090 and a VAX 8700. Printing facilities and interactive terminals are located throughout the campus and are served by the campus network. The Computing Center also provides an array of centralized services including consultation, short courses, software licensing, a campus information service and a library of public domain software.

A number of special purpose computing facilities also exist. The Computer Graphics Center (CGC) provides a centralized hardware and software facility for image processing and remote sensing. VAX computers and microcomputers are used with peripherals including image display and manipulation devices, plotters, a color graphics camera system and digitizing tables. Software includes packages for remote sensing, image processing, time series analysis and computer graphics. Other facilities in most colleges/schools provide specialized educational and research computing for their students.

BIOLOGY FIELD LABORATORY

The Biology Field Laboratory is located eight miles from the University campus and comprises a 20-acre pond, 180 acres of extremely varied vegetation types and a modern laboratory building. The latter contains two laboratories, one for class use and another principally for research.

The many unique ecological situations found in this area make it ideal for use by advanced classes of most biological science departments. Likewise, the area is well adapted to a variety of research projects by faculty, graduate students and undergraduates because of its habitat diversity. The close proximity of the laboratory facility to the campus makes possible many types of behavioral, physiological, ecological, taxonomic and limnological studies that could be accomplished only with great difficulty at other locations.

CENTER FOR COMMUNICATIONS AND SIGNAL PROCESSING

In 1982 NCSU was selected as a site for an industry/university/government cooperative research center for communications and signal processing. The National Science Foundation awarded the University a five-year grant totaling \$650,000 to be used in conjunction with company membership fees to begin operation of the Center. As of July, 1989, the Center had the following industrial members: AIRMICS, AT&T, Bell South, Carolina Power and Light Company, Digital Equipment Corp., Eastman Kodak, General Electric, International Business Machines, Northern Telecom/BNR, Westinghouse Electric Corp. The mission of the Center is to perform research in the development of tools and methodologies in communications and signal processing with tangible relevance to industrial needs and with significant academic content. In addition to providing useful research services to industrial participants, the Center enhances the education of graduate students by providing them with practical and relevant research topics and the means for carrying out this research.

CENTER FOR SOUND AND VIBRATION

The Center for Sound and Vibration, established in 1969 and administered within the Department of Mechanical and Aerospace Engineering, is composed of faculty pursuing the solution of a wide variety of problems such as occur in machinery and aircraft design particularly related to vibration and sound. Graduate programs exist at M.S. and Ph.D. levels in fields such as noise and vibration control, aeroacoustics, hearing conservation, computer-aided machinery design, active control of vibration and sound, and signal processing. Outstanding experimental facilities, which include large anechoic and reverberant rooms and computer graphics equipment, are available. The Center's programs are financed largely by grants and contracts from industry and federal and state agencies.

COUNSELING LABORATORY

The Department of Counselor Education maintains a special counseling facility on the fifth floor of Poe Hall. The laboratory is staffed by professionally trained graduate students under the supervision of departmental faculty. The major emphasis is on helping a wide variety of persons who face educational, career and personal decisions through short-term counseling and advising. Occupational exploration and aptitude testing are often included. A minimal fee (\$10.00) is charged. Appointments are available during the fall and spring semesters.

DIAGNOSTIC TEACHING CLINIC

The Diagnostic Teaching Clinic is operated by the graduate program in special education within the College of Education and Psychology for the purposes of providing graduate students with opportunities to gain both observational and applied clinical experience in diagnosing and teaching handicapped children of all ages. The clinic accepts referrals from local school systems and from nonpublic school agencies, and the students and staff evaluate the referred children, develop educational programs for them in conjunction with the referring agency and demonstrate teaching techniques for the benefit of those persons who will work with the children. This clinic is open during the day, late afternoon and early evening hours during the fall and spring semesters and throughout the summer months and is utilized by graduate students from several departments with allied curricula in education and psychology.

ELECTRIC POWER RESEARCH CENTER

The Electric Power Research Center is a university/industry cooperative research center recently established within the NCSU College of Engineering. The Center is funded by the University and sponsoring organizations from the various sectors of the electric utility and power industry. The purpose of the Center is to engage in collaborative efforts aimed at enhancing the excellence of research and graduate-level degree programs in electric power systems engineering. This primary purpose is accomplished by providing support for interested faculty and students to be involved in basic and applied research directly relevant to the needs of the multifaceted electric power industry. Motivation to work with the Center derives from the close university/industry interaction, the leverage afforded to an industrial sponsor's membership dues and the enhanced professional and research opportunities provided to faculty and students in electric power engineering.

While the current research program involves faculty from the Department of Electrical and Computer Engineering and the Department of Nuclear Engineering, the Center will facilitate access to all the various resources of the University and for all sectors of the electric power industry.

ELECTRON MICROSCOPE FACILITIES

There are four electron microscope facilities at NCSU available to graduate students and faculty for research purposes. The College of Agriculture and Life Sciences (CALS) Center for Electron Microscopy is located in Gardner Hall, the Engineering Research Microscope Facility is in Burlington Engineering Labs and the Department of Wood and Paper Science Electron Microscopy Lab is in Biltmore Hall. The new College of Veterinary Medicine (CVM) Electron Microscopy Laboratory is located in the NCSU College of Veterinary Medicine on Hillsborough Street.

The CALS Center for Electron Microscopy offers complete service support in all areas of Biological Electron Microscopy. The Center has two scanning microscopes: a Philips 505T and a JEOL T-200 and four transmission electron microscopes: an Hitachi HS-8-B, an Hitachi HU-11-B, a JEOL 100-S and a Philips 400T-STEM equipped with a C-400-M computer control system. The Center is also equipped with all of the necessary biological preparatory equipment.

Formal instruction is provided through the biological sciences curriculum for transmission electron microscopy, scanning electron microscopy and ultramicrotomy. Advanced techniques are provided on an individual basis or through workshops.

The Engineering Research Analytical Instrument Facility (AIF) is equipped with 9 Hitachi scanning transmission (model H-800) and scanning electron (model S-530) microscopes, both equipped with energy-dispersive X-ray spectrometers (Tracor Northern TN 2000 and TN 5500). In addition, an ETEC autoscanner SEM with full options is maintained.

The H-800 STEM has a maximum accelerating voltage of 200 kV and a lanthanum hexaboride gun, providing high image brightness and penetration with minimal specimen damage, which is used for ceramic, metallurgical, electronic and textile materials. Computer control of all lenses and a motorized 45-degree double-tilting stage make it easy to use, and a high takeoff angle X-ray detector provides high sensitivity elementary analysis, including mapping and quantitative capability. The instrument operates in scanning, transmission and STEM modes with full diffraction capability.

The S-530 SEM accommodates large (6-inch) specimens, has an ultra-low voltage mode for uncoated surface examination and has highly automated focus and picture-taking controls for routine high-quality images. In addition to 50-angstrom resolution secondary electron pictures, the microscope is equipped with a high-resolution backscattered electron detector and a computerized quantitative X-ray spectrometer and EBIC and EBIV systems.

All microscopes are supported by complete specimen preparation and darkroom facilities and an extensive computerized image processing, analysis and measurement system. The analytical instruments center also operates an electron probe microanalyzer (AMR/3) for wavelength dispersive X-ray analysis on the micrometer level, several light microscopes and X-ray diffractometers, and an Auger electron spectrometer with ion sputtering which allows depth profiling of elemental composition.

A scanning Auger microprobe (JEOL JAMP 30) adds monolayer surface analyzing capabilities. This system features a complete analytical SEM with full automation and an Auger electron spectrometer system for qualitative and quantitative surface analysis. The system also features electron channeling capabilities.

In addition, an ion probe microanalyzer (Cameca IMS 3f) performs secondary ion mass spectrometry (SIMS) with sub-micron lateral resolution and atomic layer depth resolution and typical detection limits in the ppm-ppb range. Both oxygen and cesium ion sources are available and a digital imaging system is used to interpret the three-dimensional elemental distributions. The instrument is used particularly for engineering, electronic and biological materials.

Center personnel teach regular courses covering many of these instrument techniques as well as short courses and offer collaboration with and instruction for graduate students on an individual basis.

The Department of Wood and Paper Science Microscopy Lab is equipped with a Siemens Elmskop-1A transmission electron microscope as well as all other equipment necessary for the preparation and study of specimens. Instruction for graduate students engaged in research is on an individual need basis.

The CVM Electron Microscopy Laboratory is a facility housing a Philips 410 transmission electron microscope for biological specimens and a JOEL JSM-35 scanning electron microscope. All the back-up equipment for preparing specimens to be viewed with either instrument are housed within the Laboratory as well as complete darkroom facilities for the preparation of routine and publication material. A course covering biological scanning and transmission electron microscopy is offered yearly. The Laboratory also offers complete electron microscopy service support to those users desiring it.

HIGHLANDS BIOLOGICAL STATION

North Carolina State University is an institutional member of the Highlands Biological Foundation which provides support for the Highlands Biological Station of the University of North Carolina. This is an inland biological field station located at Highlands, North Carolina. The town of Highlands is in the heart of the Southern Appalachians at an elevation of 3,823 feet. The area has an extremely diverse biota and the highest rainfall in the eastern United States.

Facilities are available throughout the year for pre-and post-doctoral research in botany, zoology, soils and geology. The laboratory building with research rooms and cubicles and the library are well equipped for field-oriented research. Also, five cottages and a dining hall are located on the edge of a six-acre lake. In addition to 16 acres surrounding the lake, the station owns several tracts of undisturbed forested land available for research. Research grants available through the Station provide stipends for room, board and research expenses.

INTEGRATED MANUFACTURING SYSTEMS ENGINEERING INSTITUTE

The Integrated Manufacturing Systems Engineering Institute was established at North Carolina State University in 1984 to provide interdisciplinary educational, research and technology transfer program in manufacturing systems engineering. The objectives of this program are to educate engineers in the theory and practice of integrated manufacturing

systems technology; to conduct basic and applied research on topics in cooperation with industry on problems of contemporary manufacturing system; and to engage in technology transfer with industry.

Central to all aspects of the Institute's operation and activity is in the integration of computer-aided processes in the design and control of manufacturing facilities. Through both internally and externally funded research projects the Institute contributes to the solution of generic design and manufacturing engineering problems and provides a vehicle for technology transfer.

MATERIALS RESEARCH CENTER

The Materials Research Center was established in 1984 at NCSU as an interdisciplinary program involving persons representing the Department of Chemistry, Electrical and Computer Engineering, Materials Science and Engineering and Physics. The present thrust area of the Center concerning thin films and coatings serves as a focal point for this cooperative research. The experimental efforts are conducted within the four departments noted above.

MICROELECTRONICS CENTER OF NORTH CAROLINA

North Carolina State University is a participating member of the Microelectronics Center of North Carolina (MCNC) which provides support for the academic and research programs in microelectronics in North Carolina. Other participating institutions are the University of North Carolina at Chapel Hill, Duke University, North Carolina Agricultural and Technical State University, the Research Triangle Institute and the University of North Carolina at Charlotte.

Faculty and students at NCSU have access to the use of MCNC facilities on sponsored research projects and for formal academic courses including microelectronics design and fabrication laboratories. Areas of interest include systems design, systems engineering, integrated circuit fabrication technology, semiconductor materials and device physics. Departments at NCSU which are actively involved in the program include Electrical and Computer Engineering, Computer Science, Physics, Chemistry and Materials Science and Engineering.

NUCLEAR REACTOR PROGRAM FACILITIES

The Nuclear Reactor Program provides specialized nuclear facilities to the educational, industrial and governmental organizations of North Carolina for the purposes of teaching, research and service. The Program facilities include (i) the PULSTAR, a 1-megawatt research and training nuclear reactor with unique neutron irradiation capabilities, (ii) an analytical laboratory featuring neutron activation analysis and radioisotope production and measurement and (iii) a thermal-hydraulics laboratory which has developed a freon loop to simulate the operation of a pressurized water reactor. The Nuclear Reactor Program is associated with the Department of Nuclear Engineering and is located in the Burlington Engineering Laboratories on campus.

ORGANIZATION FOR TROPICAL STUDIES

North Carolina State University is an institutional member of the Organization for Tropical Studies (OTS), a consortium of North and Central American universities which maintains field research and teaching facilities in Costa Rica. Each year OTS offers a series of courses that are open to NCSU graduate students including tropical biology, agroecology, agroforestry and tropical agricultural biology. These 8-week courses, offered in winter and summer, are taught in Costa Rica and make use of a network of OTS field stations located throughout the country.

The OTS facilities in Costa Rica also provide a unique opportunity for tropical research by NCSU graduate students and faculty. The principal field station, located in the northeastern Atlantic lowlands, has excellent laboratory and housing facilities and provides

access to a 3,500-acre tract owned by OTS. Another station is located at mid-elevation in southeastern Costa Rica near the Panamanian border. OTS also utilizes various other sites, including a seasonally dry area in the northwestern part of the country and a high-elevation area at 10,000 feet in the Talamanca range. More information about OTS may be obtained through the International Programs Office.

PESTICIDE RESIDUE RESEARCH LABORATORY

The Pesticide Residue Research Laboratory is a facility in the College of Agriculture and Life Sciences devoted to research on pesticide residues in animals, plants, soils, water and other entities of man's environment. Although the laboratory is administered through the Department of Entomology, it serves the total needs of the College in cooperative research projects requiring assistance on pesticide residue analysis.

The laboratory functions as a focal point for residue research involving interdepartmental cooperation, but faculty in the laboratory also conduct independent pesticide research on persistence and decomposition in soils and plants, absorption and translocation in plants, distribution in environment and contamination of streams, estuaries and ground water.

The laboratory is equipped with the latest analytical instruments. Graduate study can be undertaken in any aspect of pesticide residues either in the Pesticide Residue Research Laboratory or in one of the cooperating departments.

PRECISION ENGINEERING CENTER

The Precision Engineering Center was established with a \$1.25 million grant from the Office of Naval Research in 1982. The goal is to develop techniques for precision manufacturing at tolerances below those attainable with current technology. For example, fabrication of electro-optical devices require manufacturing tolerances better than 1 millionth of an inch. This goal requires new methods for monitoring and controlling the parts being produced or the process being performed. Specific research objectives involve the study of metrology systems, control algorithms, machine structural dynamics, optics, materials, and microprocessors and the details of many different fabrication processes. An interdisciplinary team of faculty from Mechanical and Aerospace Engineering, Materials Science and Engineering, Computer Science and Physics along with research staff and graduate students are working together to address these research areas.

In 1985 the program was expanded with industrial and national laboratory support and in 1986, the program was funded under the University Research Initiative program at ONR for one million dollars a year for five years. These organizations foresee the need for scientists and engineers with a background in precision engineering as well as new technology to meet their growing demands for high-precision products. With this expanded base of support, the Precision Engineering Center is fulfilling these needs.

PSYCHO-EDUCATIONAL CLINIC AND LABORATORIES

The Department of Psychology operates the Psycho-Educational Clinic located in Poe Hall. The clinic provides both a service to the public and training for school psychology graduate students. School-age child assessment and program development are the major services provided. Coordination of internships and practica is also administered through this facility.

Each graduate program in psychology also has laboratory facilities, either independently or shared. Thus, the experimental psychology program has laboratories for neuropsychology, auditory and visual perception, cognition and operant behavior. There is also a training and development laboratory as well as facilities for ergonomics, applied developmental psychology, human resource development, industrial/organizational and vocational psychology and social psychology. The latter facilities include one-way viewing rooms with recording equipment.

REPRODUCTIVE PHYSIOLOGY RESEARCH LABORATORY

The Reproductive Physiology Research Laboratory administered through the Department of Animal Science includes environmental control rooms designed to provide constant levels of air temperature, humidity and light for animals involved in studies on reproduction. Facilities and equipment are available for surgery, in vitro growth of embryos, isotope labeling in embryo metabolism and transfer of embryos between females.

Support for research at both the master's and the doctoral levels is available. Students may elect a comparative approach to a specific problem in mammalian reproduction, working with several species, or they may choose to work with a single species. Generally students select a problem associated with the identification of factors influencing early prenatal development, the endocrine control of ovarian function or some aspect of elucidation and control of aberrations in mammalian reproduction.

Cooperative research is possible between the laboratory, the College of Veterinary Medicine and the Medical School or the Environmental Health Sciences Center at the University of North Carolina at Chapel Hill for those students desiring a broader training in the general area of reproductive physiology.

Students whose work is concentrated in reproductive physiology can major in either animal science or physiology with a minor in related disciplines.

SEA GRANT COLLEGE PROGRAM

The University of North Carolina Sea Grant College Program is a state/federal partnership program involving all campuses of the UNC system. A majority of its activities, however, are conducted at the NCSU campus. Sea Grant combines the University's expertise in research, extension and education to focus on practical solutions to problems in the area of coastal and marine resource use and conservation. Graduate and undergraduate research opportunities rest with individual project directors on campus and a special fellowship program administered through the program office.

SOUTHEASTERN PLANT ENVIRONMENTAL LABORATORIES PHYTOTRON

The Southeastern Plant Environment Laboratory, often referred to as the North Carolina State University Phytotron, is especially designed for research dealing with the response of plants and microorganisms to their environment. A high degree of environmental control makes possible simulation of a wide range of climates found in tropical, temperate and northern zones.

Research in the Phytotron deals with all phases of plant biology. Although the majority of the studies are conducted with agricultural crop species, the Phytotron can accommodate ecological investigations, plant biology problems of the space program, experimental taxonomy and air pollution studies as well as basic physiological and biochemical research.

The Phytotron facility is available to the resident research staff, participants in graduate research programs of North Carolina State University and to domestic and foreign visiting scientists.

TRIANGLE UNIVERSITIES NUCLEAR LABORATORY

TUNL is a laboratory for nuclear structure research. Located on the campus of Duke University in Durham, the laboratory is staffed by faculty members and graduate students in the Departments of Physics of Duke University, the University of North Carolina at

Chapel Hill and North Carolina State University. Particle accelerators are used to bombard target nuclei with an assortment of ions of accurately controlled energy spread and spin orientation. The accelerators are a 15 MeV tandem Van de Graaff accelerator and a 4 MeV Van de Graaff accelerator. Polarized and pulsed beams are available as well as a new polarized target. On-line computers are used for data collection and analysis.

Physicists from NCSU are partners in the operation of the laboratory. There is extensive collaboration with personnel from the other two participating universities and with the many visiting physicists from the United States and abroad.

Special Programs

INTERNATIONAL AREA STUDIES GROUPS

The International Area Studies Groups, comprised of faculty from across the university with common interests in an international studies area, provide a forum for sharing professional experiences; generating and identifying support sources for collaborative scholarly activities; offering seminars for the university; providing a public-service function for the campus and community at large by identifying faculty with expertise in their study area; interacting with visiting scholars and students from the geographic area specific to the study group; and serving an advisory role in institutional linkage development between NCSU and universities in the study area.

RESEARCH PROGRAM AT THE OAK RIDGE ASSOCIATED UNIVERSITIES

North Carolina State University is a member of the Council of Sponsoring Institutions of Oak Ridge Associated Universities (ORAU), a not-for-profit consortium of 49 colleges and universities and a management and operating contractor for the U.S. Department of Energy (DOE) with principle offices located in Oak Ridge, TN. Founded in 1946, ORAU identifies and helps solve problems in science, engineering, technology, medicine, and human resources and conducts research and educational programs in energy, health and the environment for DOE, ORAU's member institutions, other colleges and universities, and other private and governmental organizations.

ORAU manages competitive programs to bring students at all levels, precollege through postgraduate, as well as faculty members, into federal and private research laboratories and selects recipients of fellowships and research grants. Many programs in ORAU's various divisions are also open to participation by qualified students and faculty with short, specialized courses in nuclear-related fields being of particular interest.

The ORAU Laboratory Graduate Participation Programs enable graduate students in life, physical and social sciences, mathematics, or engineering, who have completed all degree requirements except thesis or dissertation research, to perform full-time thesis or dissertation research under the joint direction of the major professor and a DOE staff member at a participating site. Stipends vary but usually include adequate living allowance, tuition and fees.

Information is available from NCSU's representative on the ORAU Council of Sponsoring Institutions, Dr. F. D. Hart, or by writing University Programs Division, P. O. Box 117, Oak Ridge, TN 37831-0117.

UNIVERSITY PATENT AND COPYRIGHT PROCEDURES

North Carolina State University is dedicated to teaching, research and extending knowledge to the public.

It is the policy of the University to carry out its scholarly work in an open and free atmosphere and to publish results obtained therefrom freely, limited only by a short time delay in cases in which this is necessary to prepare and file applications. Patentable inventions sometimes arise out of the research activities of its faculty, staff and students which are carried out wholly or in part with University facilities. As a public service institution, the University has an interest in assuring the utilization of such inventions for the public good. Protection must be provided for at least some of these inventions through patents and the licensing thereof to encourage their development and marketing. Patents and their exploitation, however, represent only a small part of the benefits accruing from either publicly or privately sponsored research.

A portion of the research conducted by the University is supported by government and a portion by private industry. Service to the public, including private industry, is an integral part of the University's mission. As a public institution, the University, in its agreements with private industry or other private organizations, must keep the interests of the general public in view. The rights and privileges set forth in cooperative agreements or contracts, with respect to patents and copyrights developed as a result of research partly or wholly financed by private parties, must be fair and just to the inventor(s), the sponsor and the public. Research should be undertaken by the University under support from private parties only if it is consistent with and complementary to the University's goals and responsibilities to the public.

SECTION 100—Purposes:

The North Carolina State University Patent and Copyright Procedures are designed to implement the Patent and Copyright Policies of The University of North Carolina. The procedures incorporate the interests of the faculty, staff, and students, the institution, and the sponsors of research, because in many cases those interests are congruent in desiring to encourage innovation and assure broad dissemination of the results of research. These procedures are designed to stimulate and recognize creativity among the faculty, staff, and students, and to establish an institutional process that is flexible enough to accommodate the different types of research and patentable work conducted at a comprehensive research university such as NCSU. Equity and fairness are goals of the procedures in all respects, not only in the distribution of royalty, but also in recognition. Finally, these procedures should provide an efficient and timely mechanism for reaching a decision about patenting with a minimum involvement of the inventor's time so that he or she may continue to be productive in the laboratory and classroom. To this end the University employs a patents administrator whose duties include providing assistance to faculty, staff and students in matters related to inventions.

SECTION 200—Ownership:

1. As defined by the Patent and Copyright Policies of the Board of Governors of The University of North Carolina, to which these Procedures are expressly subject, North Carolina State University has an interest in all inventions of University personnel, including students, that are conceived or first actually reduced to practice as a part of or as a result of: (a) University research; (b) activities within the scope of the inventor's employment by, or official association with, the University; and (c) activities involving the use of University time, facilities, staff, materials, University information not available to the public, or funds administered by the University.

2. Faculty, staff, and students, whose inventions are made on their own time, outside the scope of their employment or association with the University and without University facilities, materials, or resources and which inventions are, therefore, their exclusive property as specified by the Patent and Copyright Policies, may submit their invention to the University for possible patenting and/or commercial exploitation and management under terms to be agreed upon by the inventor and the University.

3. The provisions of the NCSU Patent Procedures are subject to any applicable laws, regulations or specific provisions of the grants or contracts which govern the rights in inventions made in connection with sponsored research.

4. Under the terms of certain contracts and agreements between NCSU and various agencies of government, private and public corporations, and private interests, NCSU is or may be required to assign or license all patent rights to the contracting party. NCSU retains the right to enter into such agreements whenever such action is considered to be both in its best interest and in the public interest. Ordinarily, the University will not agree to grant rights in future inventions to private corporations or businesses except as set forth in these procedures.

5. All faculty, staff and students engaged in University related or sponsored research shall sign a Patent Agreement.

6. Students who are pursuing only non-research related studies shall not be obligated to sign an NCSU Patent Agreement. However, if the student should make an invention which is, or may be, subject to University ownership in accordance with the Patent and Copyright Policies, the student shall disclose the invention to the University as provided under these Procedures and the University, together with the student, shall determine an equitable resolution of ownership rights.

SECTION 300—Responsibilities of NCSU Personnel:

1. NCSU personnel who, either alone or in association with others, make an invention in which NCSU has or may have an interest shall disclose such inventions to the Vice Chancellor for Research. The Vice Chancellor for Research will promptly acknowledge receipt of disclosures and will distribute the disclosures to the Intellectual Property Committee for consideration at its next meeting.

2. For any invention in which the University has an interest, the inventor, upon request of the Vice Chancellor for Research shall execute promptly all contracts, assignments, waivers or other legal documents necessary to vest in the University or its assignees any or all rights to the invention, including complete assignment of any patents or patent applications relating to the invention.

3. NCSU personnel may not: (a) sign patent agreements with outside persons or organizations that may abrogate the University's rights and interests either as stated in the Patent Policies or as provided in any grant or contract funding the research which led in whole or in part to making the invention, nor (b) without prior authorization, use the name of the University or any of its units in connection with any invention in which the University has an interest.

4. All faculty teaching courses in which students do work that may lead to patentable inventions should inform the students of the existence of the NCSU Patent and Copyright Policies and of these Procedures.

SECTION 400—Suggested Procedures For Record-Keeping:

1. U.S. patent practice places a premium on witnessed records when two or more parties claim the same invention. The date the idea occurred (the "conception") and the date it was put into practice form ("reduced to practice") are vital. Equally important in the eyes of the U.S. Patent Office is the "diligence" shown by contending inventors. They must prove that they regularly pursued work on the invention, documenting their efforts on a day-by-day basis. The intent of U.S. patent laws is to recognize the first inventor; the one who originated the idea. Under these laws, the first to conceive and reduce to practice will receive a patent if his records bear out his claims; the first to conceive and the last to reduce to practice may win if his records show diligence.

2. The careful recording of ideas and laboratory data is a matter of routine for industrial researchers. Each entry is complete and up-to-date, signed and witnessed; a legal record of the day's work. Record-keeping is not nearly so simple for the academic investigator, for he or she may work at odd hours or on weekends; may be closeted in a laboratory, an office or at home; and often lacks easy accessibility to suitable witnesses. Still, the keeping of a witnessed laboratory notebook is advisable. Additionally, such records can serve as valuable repositories of new ideas.

SECTION 500—The Handling of a Disclosure:

1. When faculty or staff members make an invention, it shall be their responsibility to discuss their discovery or invention with the Department Head at which time the possibility of exploring patenting should be considered. Students should first discuss an invention with their instructor, who shall assist them in further discussion within the University. The patents administrator is available to discuss possible inventions and to assist faculty, staff and students in the preparation of disclosures. If the invention appears to be a matter that should be considered for patenting, the inventor(s) should prepare a disclosure utilizing guidelines for invention disclosures which can be obtained for the patents administrator. The Department Head should transmit the disclosure through the Dean of his School to the Vice Chancellor for Research for consideration by the Intellectual Property Committee.

2. Upon receiving a disclosure, the Chairman of the Intellectual Property Committee may refer the disclosure to one of several technical advisory committees to the Intellectual Property Committee. Technical advisory committees will be appointed by the Vice Chancellor for Research and will be composed of faculty and staff who are knowledgeable and experienced in broad disciplinary or cross-disciplinary areas. These individuals will be asked to review the disclosure from the point of view of whether or not, based on their knowledge, they believe the invention, if patented, would be a strong, viable, commercial product that would have a large market. The technical advisory committee in each area will meet prior to each Intellectual Property Committee meeting if they have any disclosures presented to them, and will discuss the disclosures and make to the Intellectual Property Committee, prior to its meeting, one of the following recommendations:

A. That the disclosure has significant commercial possibilities.

B. That the disclosure does not appear to have significant commercial possibilities.

C. That the technical advisory committee could not determine, based on its knowledge, whether or not the disclosure has significant commercial possibilities.

3. The Intellectual Property Committee will review each written disclosure promptly. The inventor or a representative shall be allowed to examine all written materials submitted to the Committee in connection with the disclosure and to make a written and oral presentation to the Committee. The Committee will decide on a disposition of the invention to secure the interests of the University, the inventor, the sponsor, if any, and the public. Its decision may include, but is not limited to, one or a combination of the following:

A. To submit the disclosure for review by a patent or invention management firm or agent;

B. To make inquiries of potential licensees that may have an interest in the invention, including the financing of a patent application, where applicable;

C. To conduct a patent search concerning the patentability of the disclosure;

D. To apply for a patent with University resources (an option with limited application because of financial constraints);

E. To release University rights to the inventor subject to an agreement to protect the interests of the University, the sponsor, if any, and the public, including an obligation to pay to the University a percentage of future royalties or profits in cases where it is necessary to recognize the University's contribution;

F. To dedicate the invention to the public;

G. To waive further University interest in the invention.

4. Normally, within four weeks of the receipt of the disclosure, the inventor will be notified in writing of the decision of the Committee on (a) the equities involved including financial participation, (b) whether the University plans to file a patent application, or (c) whether the University will accept assignment of the invention for patenting, licensing and/or commercial handling as applicable. If the University chooses not to file a patent application for an invention in which it has rights, or not to license the invention, or not to dedicate it to the public, upon the inventor's written request the invention, at the Committee's discretion, may be released in writing to the inventor, with the permission of the sponsor, if any.

5. In those cases in which the University has obtained a patent without obligation to sponsors, if no arrangement has been made for commercial development within five years from the date of the issuance of the patent, the inventor(s) may request in writing an assignment of the University's patent rights. The Intellectual Property Committee will promptly either grant the request or advise the inventor of the University's plans for the development of the invention.

SECTION 600—Royalty:

1. NCSU shall share with the inventors revenue it receives from patents or inventions. As noted in Section 200 (4), specific provisions of grants or contracts may govern rights and revenue distribution regarding inventions made in connection with sponsored research; consequently, revenues the University receives from such inventions may be exclusive of payments of royalty shares to sponsors or contractors.

2. The gross royalty revenues (net amount received by the University if there is a specific agreement in a grant or contract with a sponsor) generated by a patent or invention shall be the basis upon which the inventor's royalty is calculated. Unless otherwise agreed, the inventor's share of royalty revenues shall be 25% of the gross revenue. In the case of co-inventors, the 25% of gross revenue shall be subdivided equally among them, unless the inventors, with the concurrence of the Intellectual Property Committee, determine a different share to be appropriate. Applicable laws, regulations or provisions of grants or contracts may, however, require that a lesser share be paid to the inventor. In no event shall the share payable to the inventor or inventors in the aggregate by the University be less than 15% of gross royalties received by the University.

3. To the extent practicable and consistent with State and University budget policies, the remaining revenue received by the University on account of an invention will first be applied to reimburse the University for expenses incurred by it in obtaining and maintaining patents and/or in marketing, licensing and defending patents or licensable inventions and the remainder will be dedicated to research purposes that may include research in the inventor's department or unit, if approved by the Chancellor upon recommendation of the Intellectual Property Committee.

SECTION 700—Inventor Requests for Waiver of University Rights:

1. If an inventor believes that the invention was made outside the general scope of his or her University duties, and if the inventor does not choose to assign the rights in the invention to the University, he or she shall, in the invention disclosure, request that the Intellectual Property Committee determine the respective rights of the University and the inventor in the invention and shall also include information on the following points:

- A. The circumstances under which the invention was made and developed;
- B. The employee's official duties at the time of the making of the invention;
- C. The inventor's intention to request an acknowledgment that the University has no claim if such request is deemed appropriate;
- D. The extent to which the inventor is willing voluntarily to assign domestic and foreign rights in the invention to the University if it should be determined that an assignment of the invention to the University is not required under the Patent and Copyright Policies;
- E. The inventor's intention to request that the University prosecute a patent application if it should be determined that an assignment of the invention to the University is not required under the Patent and Copyright Policies.

SECTION 800—Publication and Public Use

1. North Carolina State University strongly encourages scholarly publication of the results of research by faculty and students. Though the Patent and Copyright Policies do not limit the right to publish, except for short periods of time necessary to protect patent rights, publication or public use of an invention constitutes a statutory bar to the granting of a United States patent for the invention unless a patent application is filed within one year of the date of such publication or public use. Publication or public use also can be an immediate bar to patentability in certain foreign countries.

2. In order to preserve rights in unpatented inventions, it shall be the duty of the inventor, or of his or her supervisor if the inventor is not available to make such report, to report immediately to the Vice Chancellor for Research any publication, submission of manuscript for publication, sale, public use, or plans for sale or public use, of an invention, if a disclosure has previously been filed. If an invention is disclosed to any person who is not employed by the University or working in cooperation with the University upon that invention, a record shall be kept of the date and extent of the disclosure, the name and address of the person to whom the disclosure was made, and the purpose of the disclosure.

After disclosure to the Intellectual Property Committee, the inventor shall immediately notify the Vice Chancellor for Research of the acceptance for publication of any manuscript describing the invention or of any sale or public use made or planned by the inventor.

SECTION 900—Contractual Arrangements:

1. North Carolina State University will follow Federal Regulations with respect to election of title in contracts and grants with Federal agencies.

2. The University normally reserves the right to ownership of patents on inventions arising out of research supported in whole or in part by grants or contracts with non-governmental organizations or firms. Contracts or agreements which are entered into between the University and such organizations or agencies should contain clauses setting forth such a reservation unless deviations therefrom are requested by the sponsor and approved by the Vice Chancellor for Research. In the interest of fair treatment to the sponsor in consideration for an investment and in the interest of discharging the University's obligation to the public in the application of its facilities and employee time and talent, special provisions may be negotiated by the Vice Chancellor for Research in such non-government sponsored contracts on options such as the following:

A. The University will retain rights to patents arising out of such sponsored research but, if a significant portion of the research costs are borne by the sponsor, including direct costs, the sponsor may be assured a non-exclusive, non-assignable license at a most favorable royalty rate for the use of the patent.

B. Other patent licensing alternatives may be negotiated in the research contract based on factors which will promote effective and expeditious transfer of the technology. Research sponsors are encouraged to seek guidance from the Office of the Vice Chancellor for Research.

C. In order to protect the potential patent interests of both parties in such contracts in which the sponsor is accorded patent rights, the following procedure may be specified:

"When in the course of the sponsored research project the investigator or investigators conceive or reduce to practice some discovery which appears to be patentable, then the inventor(s) will immediately inform the sponsors and the University of such discovery and will, for a specified period as negotiated (normally three months but in any case not more than twelve months), make available to the sponsor all pertinent information and disclosures which may be required for the development of an appropriate patent application. During this period, the investigators agree not to disclose this material to the public and agree to cooperate in the sponsor's effort to secure the patent. At the end of this agreed period, the investigators and the University will be free to proceed with publications and making public such other documents as they may choose. With the exception of the above mentioned agreed period, the University will operate industry sponsored contracts in the normal manner with no other special considerations being given to the sponsor. Under no circumstances will the sponsor have the right to prevent the publication of material or information derived during the conduct of the program or as a result thereof other than for the agreed period indicated above."

Prior written agreement of the investigators involved in research investigations to be carried out under these conditions must be secured by the University to enable the University to discharge its agreed obligations under such a contract.

SECTION 1000—Patent Management and Administration:

1. North Carolina State University recognizes that the evaluation of inventions and discoveries and the administration, development and processing of patents and licensable inventions involves substantial time and expense and requires talents and experience not ordinarily found among its faculty and staff; therefore, it employs the Director, Office of Technology Administration to provide assistance. The University may contract with outside agents for certain services. It may enter into a contract or contracts with an outside organization covering specific inventions or discoveries believed to be patentable and patents developed therefrom or covering all such inventions, discoveries and patents in which the University has an interest. The University may manage an invention using its own resources.

2. The Chancellor shall appoint an Intellectual Property Committee consisting of no fewer than three members. The Vice Chancellor for Research shall serve as Chairman of the

Committee. The Committee shall review and recommend to the Chancellor or the Chancellor's delegate changes in these Procedures, decide upon appropriate disposition of invention disclosures, resolve questions of invention ownership, recommend to the Chancellor the expenditure of invention royalties, and make such recommendations as are deemed appropriate to encourage disclosures and to assure prompt and effective handling, evaluation, and prosecution of invention opportunities and to protect the interests of the University and the public. The Director of the Office of Technology Administration shall serve as staff for the Committee and shall attend all meetings.

SECTION 1100—Copyright Procedures:

1. As a general rule, all rights to copyrightable material are the property of the author. The distribution or royalties, if any, is a matter of arrangement between the author and his or her publishers or licensees. Different treatment may be accorded by the University in case of specific contracts providing for an exception, in cases where the University or sponsor may employ personnel for the purpose of producing a specific work, where different treatment is deemed necessary to reflect the contribution of the institution to the work, as in the case of software or audiovisual material, or where a sponsored agreement requires otherwise. All agreements concerning copyright ownership should be in writing and should be signed by the parties and approved by the Vice Chancellor for Research prior to the commencement of the work.

2. An institute, center, or other unit of the University that is itself a publisher and that engages faculty members and other employees to write for publication by that unit as a part of their professional duty or produce other copyrightable materials, such as audiovisual materials or computer software, may, subject to the approval of the Vice Chancellor for Research, adopt rules providing that copyright on materials prepared by such faculty members and other employees in the course of their professional work for that unit vests in the University and not in the author.

3. Guidelines and procedures for determining faculty, staff and student ownership of computer software were adopted by the NCSU Board of Trustees, effective July 1, 1987, and are available under separate cover from the Office of the Vice Chancellor for Research or the Office of Technology Administration.

POLICY ON ILLEGAL DRUGS

The following policy on illegal drugs was adopted by the North Carolina State University Board of Trustees on April 16, 1988:

PURPOSE

Reflecting its concern over the threat which illegal drugs constitute to higher education communities, the Board of Governors of the University of North Carolina adopted a policy on illegal drugs on January 15, 1988. The Board of Governors' policy requires each constituent institution's Board of Trustees to develop a policy on illegal drugs applicable to all students, faculty members, administrators, and other employees. The policy for each campus must address particular circumstances and needs while being fully consistent with specified minimum requirements for enforcement and penalties.

To assist North Carolina State University in its continuing efforts to meet the threat of illegal drugs, and to comply with the Board of Governors' policy, the Board of Trustees adopts the policy set forth below. This policy is intended to demonstrate the University's primary commitment to education, counseling, rehabilitation, and elimination of illegal drugs, as well as its determination to impose penalties in the event of violation of state and federal drug laws consistent with all due process protection rights.

EDUCATION, COUNSELING AND REHABILITATION

North Carolina State University shall maintain a program of education designed to help all members of the University community avoid involvement with illegal drugs. The educational program shall emphasize the incompatibility of the use or sale of illegal drugs with the goals of the University, the legal consequences of involvement with illegal drugs,

the medical and psychological implications of the use of illegal drugs, and the ways in which illegal drugs jeopardize an individual's present accomplishments and future opportunities. Specific elements of the education program are:

1. Publicizing the University's policy in the Student Code of Conduct, the undergraduate and graduate catalogs, and other publications distributed to students, faculty, administrators, and other employees. The latter publications include the official bulletin, the Student Handbook, the Faculty Handbook, the Advisers' Handbook, and the Human Resources newsletter.
2. Continuing and expanding the drug education program conducted by Student Health Service.
3. Continuing development of courses on drug education.
4. Continuing the drug education component of the employees' Wellness Program.
5. Increasing the awareness and utilization of the University's Employee Assistance Program (EAP).

The University shall disseminate information about drug counseling and rehabilitation services that are available to members of the University community. Persons who voluntarily avail themselves of such services shall be assured that applicable professional standards of confidentiality will be observed and that such participation will not be the basis for disciplinary action. Specific counseling and rehabilitation efforts include:

1. Continuing the evaluation and referral services of the Counseling Center for outpatient and in-patient rehabilitation.
2. Continuing the consultation and evaluation portions of the Student Health Service's drug education program.
3. Utilizing the Employee Assistance Program's referral to existing community-based counseling and rehabilitation services.

ENFORCEMENT AND PENALTIES

Students, faculty members, administrators, and other employees are responsible, as citizens, for knowing about and complying with the provisions of North Carolina law that make it a crime to possess, sell, deliver, or manufacture those drugs designated collectively as "controlled substances" in Article 5 of Chapter 90 of the North Carolina General Statutes. The University will initiate its own disciplinary proceeding against a student, faculty member, administrator, or other employee when the offense is deemed to affect the interests of the University. Penalties will be imposed by the University in accordance with procedural safeguards applicable to disciplinary actions against students, faculty members, administrators, and other employees, as required by Section 502D (3) and Section 603 of the University Code, by Board of Governors' policies applicable to other employees exempt from the State Personnel Act, and by regulations of the State Personnel Commission. The penalties to be imposed by the University may range from written warnings with probationary status to expulsions from enrollment and discharges from employment. However, the following minimum penalties, as prescribed by the Board of Governors, shall be imposed for the particular offenses described.

Trafficking in Illegal Drugs

1. For the illegal manufacture, sale or delivery, or possession with intent to manufacture, sell or deliver, of any controlled substance identified in Schedule 1, N.C. General Statutes 90-89, or Schedule 11, N.C. General Statutes 90-90 (including, but not limited to, heroin, mescaline, lysergic acid diethylamide, opium, cocaine, amphetamine, methoqualine), any student shall be expelled and any faculty member, administrator or other employee shall be discharged.
2. For a first offense involving the illegal manufacture, sale or delivery, or possession with intent to manufacture, sell or deliver, of any controlled substance identified in Schedules III through VI, N.C. General Statutes 90-91 through 90-94 (including, but not limited to, marijuana, phenobarbital, codeine), the minimum penalty shall be suspension from enrollment or from employment for a period of at least one semester or its equivalent.* For a second offense, any student shall be expelled and any faculty member, administrator, or other employee shall be discharged.

*Employees subject to the State Personnel Act are governed by regulations of the State Personnel Commission. Because the minimum penalty specified in this section and required by the Board of Governors exceeds the maximum period of suspension without pay that is permitted by the State Personnel Commission regulations, the penalty for a first offense for employees subject to the State Personnel Act is discharge.

Illegal Possession of Drugs

1. For a first offense involving the illegal possession of any controlled substance identified in Schedule I, N. C. General Statutes 90-89, or Schedule II, N.C. General Statutes 90-90, the minimum penalty shall be suspension from enrollment or from employment for a period of at least one semester or its equivalent.*
2. For a first offense involving the illegal possession of any controlled substance identified in Schedules III through VI, N.C. General Statutes 90-91 through 90-94, the minimum penalty shall be probation, for a period to be determined on a case-by-case basis. A person on probation must agree to participate in a drug education and counseling program, consent to regular drug testing, and accept such other conditions and restrictions, including a program of community service, as the Chancellor or the Chancellor's designee deems appropriate. Refusal or failure to abide by the terms of probation shall result in suspension from enrollment or from employment for any unexpired balance of the prescribed period of probation.
3. For second or other subsequent offenses involving the illegal possession of controlled substance, progressively more severe penalties shall be imposed, including expulsion of students and discharge of faculty members, administrators or other employees.

SUSPENSION PENDING FINAL DISPOSITION

When a student, faculty member, administrator, or other employee has been charged by the University with a violation of policies concerning illegal drugs, he or she may be suspended from enrollment or employment before initiation or completion of regular disciplinary proceedings if, assuming the truth of the charges, the Chancellor or, in the Chancellor's absence, the Chancellor's designee concludes that the person's continued presence within the University community would constitute a clear and immediate danger to the health or welfare of other members of the University community; provided, that if such a suspension is imposed, an appropriate hearing of the charges against the suspended person shall be held as promptly as possible thereafter.

COORDINATOR OF DRUG EDUCATION

The University Counsel will serve as coordinator of drug education and, acting under the authority of the Chancellor, will be responsible for overseeing all action and programs relating to this institutional policy.

IMPLEMENTATION AND REPORTING

This North Carolina State University policy on illegal drugs shall be effective on the beginning of the fall semester of 1988.

Annually the Chancellor shall submit to the Board of Trustees a report on campus activities related to illegal drugs for the preceding year. The report shall include, as a minimum, the following: (1) a listing of the major education activities conducted during the year; (2) a report on any illegal drug-related incidents, including any sanctions imposed; (3) an assessment by the Chancellor of the effectiveness of the campus program; and (4) any proposed changes in the policy on illegal drugs. A copy of the report shall be provided to the President.



FIELDS OF INSTRUCTION

COURSE DESCRIPTIONS

The course descriptions are planned for the academic years 1989-1990 and 1990-1991, unless indicated otherwise. Some listed courses may not be taught, however, if registration for a course is insufficient, or if faculty or facilities are not available.

Consent of the department is required for all practicum and individual special topics or special problems courses as well as internships and thesis or dissertation research. In a typical course description, the semester hours of credit, the number of actual lecture and laboratory hours of meeting per week and the term or terms in which the course is offered are shown in this manner: 2(1-2) F,S,Sum. or 1-3 F,S,Sum.

In the first example, the "2" indicates the number of semester hours credit given for satisfactory completion of the course. The "(1-2)" indicates that the course meets for one hour of lecture and two hours of laboratory work each week. In the second example, the "1-3" indicates that a maximum of three and a minimum of one semester hours' credit can be earned. This is to be arranged with the instructor. The "F" designates that the course is to be given in the fall semester. Likewise, the "S" designates spring and the "Sum.," summer.

ABBREVIATIONS USED IN COURSE LISTINGS

Abbreviations used in the course listings are:

- alt. yrs., alternate years
- CI, consent of instructor
- coreq., corequisite

grad. standing, admitted to the Graduate School
hrs., hours
jr., junior
lab., laboratory
lect., lecture
PBS, Post-baccalaureate Studies status
peq., prerequisite
sr., senior
undergrad., undergraduate.

Courses at the 600 level are not ordinarily open to undergraduates, although occasional exceptions are made for senior honor students.

For 400-level course descriptions, see the Undergraduate Catalog.

Adult and Community College Education

GRADUATE FACULTY

Professor E. J. Boone, Head

Professor R. W. Shearon, Associate Head and Graduate Administrator

Professors: G. L. Carter Jr., J. C. Glass Jr., R. D. Mustian; *Extension Professor:* D. R. Proctor; *Professors Emeriti:* M. P. Burt, W. L. Carpenter, G. Hyatt Jr., M. S. Knowles; *Associate Professors:* A. Fingeret, R. T. Liles, L. I. Rendon, T. A. Tollefson; *Visiting Associate Professors:* G. J. Andrews, P. Meyer; *Associate Professors Emeriti:* W. L. Gragg, E. E. White; *Assistant Professor:* S. A. J. Colin III; *Adjunct Assistant Professors:* R. A. Berlam, E. S. Knott, R. J. Plummer

The Department of Adult and Community College Education is administered by the Colleges of Education and Psychology and Agriculture and Life Sciences. Program offerings lead to the Master of Science, Master of Education and Doctor of Education degrees. The program is directed toward administrators, supervisors, programmers, staff development officers, and instructors in community colleges, extension systems, adult and continuing education in higher education and the professions, and other adult education organizations.

The interdisciplinary curriculum focuses on acquiring an integrated conceptual and theoretical framework, derived from the behavioral and social sciences and education, and developing abilities to plan, administer and effect viable and relevant educational programs of change with learner systems in both formal and nonformal contexts. Opportunities are provided to bridge the gap between theory and hands-on practice.

Each student's study program is individualized. Programs of study may be developed within an area(s) of scholarship alone, or with a focus on a professional field of application. The areas of scholarship include (1) history, philosophy and foundations of adult and community college education, (2) administration/organization development, (3) programming/evaluation and accountability, (4) learning/instruction and (5) systematic inquiry/research. While a student must be competent in all five areas, a focus may be developed in one or more of the areas.

Professional specialization is offered in either community college education, or extension education, or adult and continuing education, with several areas of concentration: (1) community college administration, (2) community college instruction, (3) extension administration, (4) extension programming, (5) international extension education, (6) educational gerontology, (7) continuing professional education and (8) education for special adult populations (literacy education, developmental studies). The M.S. and M.Ed. programs require a minimum of 30 or 36 credit hours, respectively. The Ed.D. program requires extensive research work and may include participation in a supervised internship experience. The doctoral program must be completed within seven years from the date of admission. One academic year of full-time residency is required. In addition to Graduate School admission requirements, the department may require recent GRE scores (verbal and quantitative), the Miller Analogies Test, a writing test, a narrative statement that describes the applicant's career objectives and specific objectives for enrolling in the program, and interviews by the ACCE Admissions Committee and other Graduate Faculty members.

For descriptions of the adult and community college education courses listed below, see education.

SELECTED ADVANCED UNDERGRADUATE COURSE

ED 478 Extension as Non-formal Education. *Freq.: Advanced undergrad. or PBS.* 3(3-0) S.

FOR GRADUATES AND ADVANCED UNDERGRADUATES

ED 500 Community College and Two-year Postsecondary Education. 3(3-0) F,S.

ED 503 The Programming Process in Adult and Community College Education. 3(3-0) F,S.

ED 505 Group Process in Adult and Community College Education. 3(3-0) F,S.

ED 510 Adult Education: History, Philosophy, Contemporary Nature. 3(3-0) F,S.

ED 537 The Extension and Public Service Function in Higher Education. 3(3-0) F,Sum.

ED 538 Instructional Strategies in Adult and Community College Education. 3(3-0) F.

ED 539 Educational Gerontology. 3(3-0) S.

ED 543 Adulthood and Learning: The Later Years. 3(3-0) Alt. S.

ED 549 Finance in Adult and Community College Education. 3(3-0) S.

ED 559 The Adult Learner. 3(3-0) S,Sum.

ED 567 Education of Special Adult Populations. 3(3-0) S,Sum.

ED 579 Concepts and Principles of Evaluation Applied to Non-formal Adult Education. 3(3-0) S.

ED 585 Qualitative Research in Adult and Community College Education. 3(3-0) F.

ED 596 Topical Problems in Adult and Community College Education. *Credits Arranged. F,S,Sum.*

FOR GRADUATES ONLY

ED 600 Organizational Concepts and Theories Applied to Adult and Community College Education. *3(3-0) F,Sum.*

ED 601 Administrative Concepts and Theories Applied to Adult and Community College Education. *3(3-0) S,Sum.*

ED 696 Seminar in Adult and Community College Education. *1-3. F,S.*

Agricultural Communications

AC 590 Special Topics in Agricultural Communications. *Preq.: Sr. or grad. standing. 1-6.* Special Topics may be selected for study in the theoretical approaches to communications problems or experimental investigation with instructor guidance. Graduate Staff

Agricultural Education

For a listing of graduate faculty and departmental information, see education.

Air Conservation

The air conservation faculty includes some 50 faculty members representing 20 departments in four schools. It is the intent of this faculty and the associated program to provide training for students in the many disciplines related to air conservation. Such areas as air sampling, biological effects, air-quality management, sources, meteorology, law and economics and business are all important aspects covered by course offerings and research projects.

A graduate student desiring to minor in air conservation will have on his or her committee a member of the air conservation faculty from outside the individual's major department, representing this minor field. While there are no restrictions on the major, students minoring in air conservation should have a strong background in the life sciences, the physical sciences or engineering. The minor program will normally consist of 9 or more credits for the master's degree, 15 or more for the doctorate.

A variety of courses bearing on different aspects of the air conservation problem may be taken on this campus, at UNC-Chapel Hill or at Duke. The listing below shows relevant courses available at North Carolina State University. For courses at Duke and Chapel Hill see the appropriate catalogs.

Air Pollutants and Their Sources

CE 576 Atmospheric Pollution.

Meteorology and Pollutant Transport

MEA 555 Meteorology of the Biosphere.

MEA 556 Air Pollution Meteorology.

MEA 627 Atmospheric Turbulence and Diffusion.

Air Sampling and Analysis

- ST 511 Experimental Statistics for Biological Sciences I.
 ST 515 Experimental Statistics for Engineers.
 CH 517 Physical Methods of Elemental Trace Analysis.

Effects on Human, Animal and Plant Receptors

- FOR 353 Air Photo Interpretation and Photogrammetry.
 TOX 515 Environmental Toxicology.
 BO 561 Physiological Ecology.

Air Quality Management

- MAE 409 Particulate Control in Industrial Atmospheric Pollution.
 WPS 525 Pollution Abatement in Forest Products Industries.
 MAE 570 Theory of Particulate Collection in Air Pollution Control.

Air Quality Law and Institutions

- UNI 495 Special Topics in University Studies (Environment and Law).
 PA 511 Public Administration.

Air Conservation Economics

- EB 401 Economic Analysis for Non-Majors.
 OR 501 Introduction to Operations Research.
 EB 515 Environmental and Resource Policy.

Communications concerning the air conservation program, including inquiries from students wishing to minor in air conservation, should be directed to the Chairman, Air Conservation Faculty, Department of Chemical Engineering, P.O. Box 7905, North Carolina State University, Raleigh, North Carolina 27695-7905.

Animal Science

GRADUATE FACULTY

Professor L. S. Bull, *Head*

Associate Professor K. L. Esbenshade, *Graduate Administrator*

Professors: J. H. Britt, K. R. Butcher, E. V. Caruolo, A. J. Clawson, D. G. Davenport, E. J. Eisen, R. W. Harvey, W. L. Johnson, E. E. Jones, J. R. Jones, J. G. Lecce, C. L. Markert, B. T. McDaniel, B. R. Poulton, A. H. Rakes, H. A. Ramsey, O. W. Robison, F. D. Sargent, J. C. Wilk; *Extension Professor:* D. P. Wesen; *Professors Emeriti:* E. R. Barrick, R. F. Behlow, L. Goode, C. A. Lassiter, J. M. Leatherwood, J. E. Legates, R. D. Mochrie, R. M. Myers, I. D. Porterfield, F. H. Smith, L. C. Ulberg, G. H. Wise; *Associate Professors:* M. T. Coffey, W. J. Croom Jr., R. L. McCraw, R. M. Petters, K. R. Pond, J. W. Spears, L. W. Whitlow; *Associate Professors Emeriti:* E. U. Dillard, J. J. McNeill; *Assistant Professors:* J. D. Armstrong, W. L. Flowers, S. P. Washburn

ASSOCIATE MEMBERS OF THE DEPARTMENT

Professor (USDA): J. C. Burns; *Associate Professors:* W. M. Hagler, Jr., M. D. Whitacre

The Department of Animal Science offers programs of graduate study leading to the Master of Agriculture, Master of Science and Doctor of Philosophy degrees. Animal science offers an opportunity for training in a diversity of basic sciences and the integration of such knowledge into the framework of a living system. Students may major not only in animal science but also in any one of the following disciplines: biochemistry, genetics, microbiology, nutrition and physiology. Animal science majors may specialize in one or more of these basic disciplines or in the more applied areas of management and production. The animal science major provides for the student who prefers a multidisciplinary approach. Majors in a basic discipline are not only educated in it but have the added capability of integrating such knowledge into a living system, *i.e.*, the domestic animal. Minors can be obtained in any of the disciplines listed or in a variety of other areas.

Modern laboratories, specialized equipment and many different species of animals are available as research tools. A program of course work and a research project are developed for each student in accord with one's educational objectives. The primary goal is to provide the student with a challenging opportunity to develop his or her creative ability so that it may contribute significantly to a chosen discipline.

SELECTED ADVANCED UNDERGRADUATE COURSES

ANS 401 Reproductive Physiology. *Preq.: ZO 421. 3(2-3) F.*

ANS 402 Beef Cattle Management. *Preq.: ANS 204. 3(2-3) S.*

ANS 403 Swine Management. *Preq.: ANS 204. 3(2-3) F.*

ANS 404 Dairy Cattle Management. *Preq.: ANS 204. 3(2-3) S.*

ANS 405 Lactation. *Preq.: BS 100. 3(2-3) S.*

ANS 406 Sheep Management. *Preq.: ANS 204. 3(2-3) S. Alt. yrs.*

ANS 410 Horse Science. *Preq.: ANS 310 or CI. 3(2-2) S.*

ANS 411 Breeding and Improvement of Domestic Animals. *Preq.: GN 411. 3(3-0) F.*

ANS (PO, NTR) 415 Comparative Nutrition. *Preq.: CH 220 or both 221 and 223. 3(3-0) F.*

ANS (NTR) 419 Human Nutrition in Health and Disease. *Preqs.: ANS (NTR, PO) 415 or FS 400, BCH 451. 3(3-0) S.*

FOR GRADUATES AND ADVANCED UNDERGRADUATES

ANS 500 Advanced Ruminant Nutrition. *Preq.: ANS 204 or ANS 415. 3(3-0) Sum. Alt. yrs. Advanced concepts in ruminant nutrition for the practicing agricultural professional. Protein, energy, vitamin and mineral nutrition in relationship to the nutritional needs and*

practical feeding of beef cattle, dairy cattle, sheep and goats. New developments in feeding systems, feed additives and the prevention and treatment of metabolic disorders.

Pond, Croom, Whitlow

ANS (PHY) 502 Reproductive Physiology of Vertebrates. *Preqs.: ZO 421. 3(3-0) S.* Emphasis placed on discussions of mechanisms which control the reproductive processes. Mechanisms which are species-limited compared with those shared by all species. Current knowledge of some subsystems investigated in detail while others referred to in reviews of well-documented research findings.

Britt, Petters

ANS (GN) 508 Genetics of Animal Improvement. *Preqs.: GN 411, ST 511. 3(3-0) S.* Emphasis placed on the utilization of basic principles of population and quantitative genetics in animal improvement. Factors affecting genic and genotypic frequencies and methods of estimating genetic and nongenetic variance, heritabilities and breeding values presented. The roles of mating systems and selection procedures in producing superior genetic populations examined.

Robison

ANS 510 Advanced Livestock Management. *Preqs.: ANS 402 or ANS 403 or ANS 404. 3(3-0) S.* An advanced study of beef cattle, dairy cattle and swine management practices with particular emphasis on input-output relationships and the consequences of alternative management decisions. Problem. (Offered on-campus in even-numbered years.)

Davenport

ANS (NTR) 516A,B,C,D Animal Nutrition Research Methods. 1-4 S. (See nutrition.)

ANS 520 Tropical Livestock Production. *Preqs.: Six hrs. of ANS at 400 level. 3(3-0) F.* Modern principles of feeding, genetics, forage production and management applied to improvement of meat and dairy animals in tropical, subtropical and high-altitude environments. Considers biological and socio-economic constraints to development of livestock industry. Discussion of climatic effects on production applied to U. S. conditions and to developing tropical countries.

Johnson

ANS (NTR) 540 Ruminant Physiology and Metabolism. *Preqs.: BCH 451 or 551, ZO 421. 3(3-0) F. Alt. yrs.* Detailed discussion of the ruminant digestive system, its dependent microbial fermentation and the unique aspects of ruminant tissue metabolism. Emphasis given to the understanding of the interdependent relationship between the rumen microbial fermentation and the host animal's physiology and metabolism. The effects of changes in diet and physiological state and their relationship to various digestive and metabolic dysfunctions discussed.

Croom

ANS (PHY) 580 Mammalian Endocrine Physiology. *Preqs.: BCH 451, ZO 421. 3(3-0) F. Alt. yrs.* Detailed discussion of the mammalian endocrine system with emphasis on the functional aspect, chemistry and mode of action of specific hormones secreted from major endocrine glands. Modern biochemical and physiological principles of hormonal integrations and neuroendocrine integration examined.

Graduate Staff

ANS 590 Topical Problems in Animal Science. *Credits arranged. Max. 6 F,S.* Special problems selected or assigned in various phases of animal science.

Graduate Staff

FOR GRADUATES ONLY

ANS (GN) 603 Population Genetics in Animal Improvement. *Preqs.: ST 512, GN 506. 3(3-0) F.* A study of the forces influencing gene frequencies, inbreeding and its effects, and alternative breeding plans.

Eisen

ANS (NTR, PO) 605 Mineral Metabolism. *Preqs.: ANS (NTR, PO) 415 or BCH 551, BCH 451 and ZO 421. 3(3-0) F.* Requirements, function, distribution, absorption, excretion and toxicity of minerals in humans and domestic animals. Interactions between minerals and other factors affecting mineral metabolism or availability. Emphasis on mechanisms associated with mineral functions and the metabolic bases for the development of signs of deficiency.

Spears

ANS 606 Animal Biotechnology: Embryo Manipulation. *Freq.: ANS 502. 4(1-8) F. Alt. yrs.* Advanced training and experience in mammalian embryo manipulation including techniques of superovulation and embryo recovery, in vitro culture, parthenogenetic activation, in vitro fertilization, embryo transfer, embryo aggregation and DNA micro-injection. Petters

ANS 699 Research in Animal Science. *Credits Arranged. F,S.* A maximum of six hours allowed toward the master's degree; no limitation on credits in doctorate program.

Graduate Staff

Anthropology

For anthropology courses, see sociology and anthropology.

Architecture

GRADUATE FACULTY

Professor R. P. Burns Jr., Program Director

Associate Professor J. P. Rand, Assistant Program Director

Professors: P. Batchelor, G. Bizios, R. H. Clark, C. E. McKinney, M. Pause, G. J. P. Reuer, H. Sanoff, V. F. Shogren, E. W. Taylor; *Professors Emeriti:* G. L. Bireline Jr., J. H. Cox, H. H. Harris, H. L. Kamphoefner, D. R. Stuart; *Associate Professors:* F. C. Harmon, J. W. Place, L. W. Sanders, J. O. Tector, P. Tesar; *Visiting Associate Professor:* E. F. Harris Jr.; *Associate Professor Emeritus:* D. W. Barnes Jr.; *Assistant Professor:* F. A. Rifki; *Adjunct Lecturer:* T. C. Howard

The Master of Architecture program prepares students to assume responsible professional roles in architecture. Learning goals for students in the program include 1) developing exceptional competence in architectural design, 2) building a base of knowledge and skills necessary for professional activity, 3) developing a commitment to professional values and responsibilities, 4) discovering the variety of career roles in practice and related fields, and 5) developing as autonomous individuals, willing to assume responsibility for a lifetime of intellectual and creative growth.

Students encounter architectural problems at a variety of scales requiring analytic, conceptual and developmental abilities. The design studio is the focus of this activity, enabling students to test ideas and theories about design in the context of both "real life" and idealized problems. The final studio is devoted to a self-initiated, detailed architectural project that is carried out under the guidance of the student's graduate advisory committee.

Other course work supplements and amplifies these experiences. A rich variety of courses is available within the Architecture Department in urban and community design, architectural conservation, management, professional practice and building technology. A distinctive characteristic of the program is its context within the School of Design, which offers the additional perspectives of landscape architecture, product design and visual design. Course work may also

be taken throughout North Carolina State University and at nearby University of North Carolina at Chapel Hill and Duke University. The program's flexible curriculum offers the student considerable freedom to individualize his or her plan of study, based on personal, educational and professional goals.

The Master of Architecture is a first professional degree accredited by the National Architectural Accrediting Board. As such, it satisfies educational requirements for professional licensure and certification established by the various states and the National Council of Architectural Registration Boards. The department also offers a parallel 4 + 1 Bachelor of Architecture program which provides similar professional qualification.

The majority of recent graduates have chosen to enter private architectural practice, undertaking the rich professional challenges it offers. While acknowledging the primacy of the practice orientation, the Master of Architecture program enlarges the professional framework to include alternative, nontraditional career roles as well.

Students are encouraged to exercise initiative and responsibility in realizing their personal educational goals. Student independence is seen as instrumental in helping to shape not only decision-making capabilities but future leadership potential as well.

The Department of Architecture offers three tracks to the Master of Architecture degree. Track 1 is for applicants with a four-year undergraduate degree in architecture and may be completed in two years of full-time study. Track 2 is for applicants holding a five-year NAAB-accredited Bachelor of Architecture degree and normally requires three semesters in residence. Track 3 is for students with degrees in fields other than architecture. This normally requires four semesters of preparatory work before entering the final two-year program of graduate study. Some applicants with design-related academic or professional experience may be able to complete the preparatory work in less than four semester; each case is evaluated individually.

SELECTED ADVANCED UNDERGRADUATE COURSE

ARC 400 Architectural Design. *Preq.: DF 102. 6(0-9) F.*

ARC 402 Architectural Design: History. *Preqs.: ARC 302, ARC 400, ARC 441, ARC 494. 6(0-9) S.*

ARC 403 Pre-Graduate Architectural Design (Series). *Track 3 M.Arch. students only. Maximum of 24 hours 6(0-12) F,S.*

ARC 412 Environmental Control Systems and Site Design. *Preq.: ARC 211. 3(3-0) S.*

ARC 441 History of Contemporary Architecture. *Preq.: Jr. standing or DN 141, 142. 3(3-0) F.*

ARC 447 Ideas in American Architecture I: 1865-1893. *Preq.: Jr. standing. 3(3-0) F. Alt. yrs.*

ARC 448 Ideas in American Architecture II: 1893-1918. *Preq.: Jr. standing. 3(3-0) S. Alt. yrs.*

ARC 449 Urban Form and Structure. *Preq.: Jr. standing. 3(3-0) F.*

ARC 451 Illumination and Design. *Preq.: ARC 253. 3(2-2) S. Alt. yrs.*

ARC 452 Environmental Control Systems and Design. *Preq.: ARC 253. 3(2-2) S. Alt. yrs.*

ARC 457 Architectural Construction Systems. *Preq.: DN 254. 3(2-3) S.*

ARC 494 Practicum in Architecture. *Preqs.: Jr. standing in Architecture; 3.0 or better GPA; written approval of dept. head. 3-6 CH.*

ARC 495 Independent Study in Architecture. *Preq.: Jr. standing in Architecture; 3.0 or better GPA; approval of dept. head. 1-3 CH.*

FOR GRADUATES AND ADVANCED UNDERGRADUATES

ARC 501 Professional Architecture Studio I. *Preqs.: BEDA degree or equivalent and CI; Coreq.: ARC 510. 6(0-12) F,S.* Design studio investigations aimed at the development of an understanding of the major issues confronting the contemporary architect and at the expanding of problem solving abilities in architectural design.

ARC 502 Professional Architecture Studio II. *Preqs.: ARC 501; ARC 510 and CI. 6(0-12) F,S.* Design investigations aimed at the development of an understanding of the major issues confronting the contemporary architect and at the expanding of problem solving abilities in architectural design. This is an individualized, final project studio.

ARC 521, 522 Advanced Architectural Structures I, II. *Preq.: (521) DN 352; (522) ARC 521. 3(3-0) F,S.* Gravity and non-gravity loads on structures; comparative behavior of structural materials; comparative behavior of simple structural systems; approximate and exact analysis procedures as applied to systems; principles of approximate and exact design in timber, steel and reinforced concrete; architectural/structural/mechanical compatibility in systems; basic principles of foundation analyses and design.

ARC 531, 532 Advanced Building Technology I, II. *Preqs.: DN 253, 254. 2(1-3) F,S.* A synthesis of studies in building science undertaken in previous courses. Material assemblies in practical applications, dimensional characteristics of mechanical and construction systems for buildings, and special projects in selected areas of building science.

ARC 542 Investigations in Recent World Architecture. *Preqs.: Six hrs. architectural history/theory and sr. standing. 3(2-1) S. Alt. yrs.* A lecture-seminar course intended to provide a description and analysis of recent developments in architectural design through an examination of projects by many of the world's most important architects. Primary emphasis placed on emerging design concepts and theories as expressed in the built architecture and the visionary proposals of the past two decades.

ARC 543 Analysis of Precedent. *Preq.: Grad. standing. 3(0-3) S.* Investigation of architectural elements, relationships and ordering ideas through comparative graphic analysis of buildings designed by architects. Emphasis on buildings as physical artifacts.

ARC 544 Architectural Conservation. *Preq.: Advanced undergrad. in SOD or grad. standing. 3(3-0) S. Alt. yrs.* An examination of the many dimensions of architectural conservation and/or preservation as a significant aspect of architectural practice. Historical evolution, regulatory and economic factors, technology and pertinent design issues explored as foundations for individual case studies by class members of selected adaptive use, rehabilitation and restoration projects.

ARC 546 Theory of Building Types. *Preq.: Two ARC studios. 3(3-0) F.* Typology in its theoretical implications and practical applications in architecture. Analysis and documentation of selected building types in their historical evolution. Graphic identification of type characteristics.

ARC 551 Design Methods and Programming. *Preq.: Grad. standing or CI. 3(3-0) F.* An intensive study of a part of the design process involving the social and behavioral needs of the users through disciplined methods of data collection, analysis, organization, communication and evaluation. Emphasis upon the role of programming in the environmental design field and variety of applications used in the profession.

ARC 561 The Practice of Architecture. *3(3-0) F.* A lecture course which examines the practice of architecture, with emphasis given to both normative and emerging procedures in the private architectural firm. The role and function of the practicing architect, legal and regulatory conditions, the nature of professional services, office management and project management processes given special attention.

ARC 562 Project Processes in Architecture. *Preq.: Sr. or grad. standing. 3(3-0) S.* A course which examines the processes of project delivery in architectural practice from initiation to completion of projects. Lectures and case studies of current projects provide the means to explore the nature of architectural services involved, the roles of participants and the creative and technical issues which must be resolved.

ARC 570 Theory of Urban Form. *Preq.: Advanced undergrad. 3(3-0) F. Alt. yrs.* Theory of urban form examines the morphology of cities and their component parts, emphasizing the formal properties of urban space and structure. The first part of the course examines the descriptive properties of cities, while the second part deals with the analysis of parts of cities.

ARC 571 Urban Housing. *Preq.: Advanced undergrad. 3(3-0) S.* Interrelationships between housing and the form and structure of cities. Housing design as a function of economic, public policy, social and technological influences. Emphasis on the physical form of housing in the latter half of the twentieth century.

ARC 573 Environmental Perception. *Preq.: Grad. standing or CI. 3(3-0) S.* An intensive review of the design research literature that emphasizes people's interaction with the physical environment. Various techniques for measuring human response to the environment explored to permit students to develop and analyze their own research projects.

ARC 574 Place and Place Making. *Preq.: Grad. standing or CI. 3(3-0) F.* A seminar-lecture course which examines the definitions, concepts and emergent research findings useful in explaining the human sense of place. Particular emphasis upon those physical aspects and relationships which influence this sense of place and over which the designer has some control.

ARC 575 Participatory Design in Architecture. *Preq.: Grad. standing or CI. 3(3-0) S. Alt. yrs.* An examination of the theories and methods pertaining to the participatory design process. The course will probe the nature of advocacy design and examine successful projects in the U. S. and abroad that define a social role for architects.

ARC 581 Conceptual Issues in Architecture and Design I. *Preq.: Advanced undergrad. or grad. standing. 3(0-3) F.* An examination of current issues in American and Western society and their relation to the activities and goals of architects and designers.

ARC 582 Conceptual Issues in Architecture and Design II. *Preq.: Advanced undergrad. or grad. standing. 3(0-3) S.* An investigation into issues and values currently held by participating students and their relation to an anticipated career in architecture and design..

ARC 591 Special Seminar. *Preq.: Grad. standing. 1-3 F,S.* Seminars on subjects of current interest in design which are presented by persons not part of the regular faculty.

ARC 592 Special Topics in Architecture. *Preq.: Grad. standing or CI. 2-3 As needed.* Topics of current interest offered by faculty in the Department of Architecture. Subjects offered under this number normally used to test and develop new courses.

ARC 595 Independent Study. *Preq.: Grad. standing. 1-3 Max. 6. F,S,Sum.* Special problems and projects in various aspects of architecture developed under the direction of an architecture faculty member on a tutorial basis.

FOR GRADUATES ONLY

ARC 600 Advanced Architectural Design (Series). *Preq.: Grad. standing. 6(0-12) F,S.* Advanced studies in architectural design. Projects deal with various aspects of building design, urban design and community design in a comprehensive and integrative manner.

ARC 691 Advanced Study in Architecture. *Preq.: Grad. standing in School of Design. 1-6 As needed.* Investigation of selected problems and projects in architecture of particular interest to graduate students under the direction of a faculty member on a tutorial basis. Credits and content vary to meet the scope of the project proposal.

ARC 698 Final Project Studio in Architecture. *Preq.: 18 hrs. of ARC 600. 6(0-12) F,S.* Final project for graduate students supervised by members of their graduate advisory committee.

Artificial Intelligence

GRADUATE FACULTY

Professors: R. E. Funderlic, H. E. Schaffer, A. L. Tharp; *Associate Professors:* A. C. Chao, H. D. Levin, R. C. Luo, W. J. Rasdorf, R. D. Rodman, W. E. Snyder; *Visiting Associate Professor:* J. A. Bowen; *Adjunct Associate Professor:* M. G. Joost; *Assistant Professors:* D. R. Bahler, E. T. Sanii

Artificial intelligence is the branch of computer science concerned with designing computer systems which exhibit the characteristics normally associated with intelligence in human behavior, such as understanding language, learning, reasoning, solving problems, and so on. At NCSU, artificial intelligence is an interdisciplinary field, with faculty from several departments engaged in fundamental research and applications.

The university offers courses of study leading to a minor in artificial intelligence as part of the Master of Science and Doctor of Philosophy degrees. This option is available to all graduate students except those in computer science, who can choose artificial intelligence as an interest area.

To fulfill the academic requirements for a minor in artificial intelligence, each master's student must successfully complete at least three, and each doctoral student six, of the courses in the artificial intelligence curriculum. One of the courses must be CSC 511, Artificial Intelligence I. Other courses offered as part of the artificial intelligence curriculum include: CSC 502 Computational Linguistics; CSC 602 Computational Semantics; CSC 611 Artificial Intelligence II; CSC(ECE) 559 Pattern Recognition; ECE(CSC) 659 Computer Vision; CSC(ECE,IE) 575 Voice Communication Systems; CSC(ECE,IE) 675 Advances in Voice Input/Output Communication Systems; IE 520 Industrial Robotics. There is also a range of special topics courses covering subjects such as knowledge engineering, fuzzy reasoning, knowledge representation, artificial intelligence applications to CAD, and artificial intelligence in manufacturing. Other subjects can be added to an individual student's course of study at the discretion of his or her committee.

Graduate students in computer science who select artificial intelligence as an interest area are subject to the same academic requirements that define other interest areas within computer science.

Biochemistry

GRADUATE FACULTY

Professor P. F. Agris, Head

Associate Professor: E. S. Maxwell, Graduate Administrator

Professors: F. B. Armstrong, H. R. Horton, J. S. Kahn, I. S. Longmuir, W. L. Miller, E. C. Sisler, E. C. Theil; Professor Emeritus: S. B. Tove; Associate Professor: J. A. Knopp; Assistant Professor: C. C. Hardin

ASSOCIATE MEMBERS OF THE DEPARTMENT

Professors: E. E. Jones, R. R. Sederoff, H. E. Swaisgood; Professor Emeritus: L. W. Aurand

Biochemistry applies and extends concepts of chemistry and physics to problems in biology. The Department of Biochemistry offers Master of Science and Doctor of Philosophy degrees. The department is currently enlarging its faculty and expanding its scope, especially in the area of plant biochemistry.

A student entering graduate study in biochemistry should have a bachelor's degree in biochemistry, chemistry or a related physical or biological science. The undergraduate program should have included a minimum of two semesters of organic chemistry, two semesters of physical chemistry, one semester of introductory biochemistry and one semester of qualitative organic analysis. New students take placement examinations in organic and physical chemistry to determine their level of competence in these areas. Students who lack undergraduate courses considered essential for graduate study in biochemistry may be admitted to the graduate program, provided the deficiencies are corrected early in their graduate work.

Courses in general and experimental biochemistry are required as part of programs leading to advanced degrees in biochemistry. Other courses in biochemistry and related areas are required as recommended by the student's advisory committee. The student is expected to participate regularly in seminars and obtain teaching experience. Completion of a thesis based on original research is required for both the Master of Science and Doctor of Philosophy degrees. Research being conducted with the most modern equipment and in the area of macromolecular structure and function includes: the structure, function and dynamics of RNAs and DNAs; DNA sequences involved in gene regulation; role of hormones in regulation of genes; regulation of iron metabolism; design of therapeutic agents against lupus autoantibodies; plant hormone ethylene binding to plant cell receptors; corn smut disease genes; protein folding mechanisms; and others.

Prospective students are encouraged to write the department for more information.

FOR GRADUATES AND ADVANCED UNDERGRADUATES

BCH 540 Proteins. *Preq.: BCH 451 or equivalent. 2(4-0) F.* Graduate-level biochemistry offered as a series of four 7-week mini-courses (BCH 540, 541, 542, 543; 2 credits each). Proteins discussed in terms of their binding and catalytic properties. Secondary and tertiary structures that provide these properties explored in detail. (Taught the first 7 weeks.)
Graduate Staff

BCH 541 Nucleic Acids. *Prews.: BCH 451, BCH 540 or equivalents. 2(4-0) F.* DNA and RNA biosynthesis, structure and function discussed. Protein synthesis described as a process involving cooperative interactions of many RNAs and proteins. (Taught the second 7 weeks.)
Graduate Staff

BCH 542 Metabolism. *Preqs.: BCH 451 and BCH 540 or equivalents. 2(4-0) S.* Intermediary metabolism of carbohydrates, fatty acids and nucleic acids studied in relation to its role in supplying energy and metabolic intermediates for cell structure. If BCH 542 is taken for credit, BCH 544 cannot be taken for credit. (Taught the first 7 weeks.)
Graduate Staff

BCH 543 Biochemical Regulatory Processes. *Preqs.: BCH 451 and BCH 540 or equivalents. 2(4-0) S.* Lipid metabolism, membrane structure and function. Regulation of transcription and translation via hormones or other cellular modulators. (Taught the second 7 weeks.)
Graduate Staff

BCH 544 Intermediary Metabolism. *Preqs.: BCH 451 and BCH 540 or equivalents. 2(4-0) F.* Intermediary metabolism including carbohydrate, lipid, amino acid and nucleotide biosynthesis. Energy production and substrate/produce regulation featured. This course designed to follow BCH 540 and is for students who need training in proteins and intermediary metabolism before their second graduate semester. If BCH 544 is taken for credit, BCH 542 cannot be taken for credit. (Taught the second 7 weeks.)
Graduate Staff

BCH 552 Experimental Biochemistry. *Preqs.: CH 223; CH 315 recommended; Preq. or Coreq.: BCH 551. 3(1-6) F.* An advanced laboratory designed to give students practical experiences in purification and quantitative characterization of enzymes and nucleic acids. Studies with carbohydrates and membrane lipids also included. Credit may be applied toward biotechnology minor.
Miller

BCH (PHY) 553 Physiological Biochemistry. *Preq.: BCH 551. 3(3-0) S.* Application of biochemical methods to the elucidation of the function of whole organisms. A. Biochemistry of 1) blood, 2) water, electrolyte, acid-base balance, 3) renal function, 4) muscle metabolism, 5) central nervous system, 6) autonomic nervous system, 7) endocrine system. B. Biochemistry of adaptation to environment: 1) high and low P_{O_2} , 2) hot and cold, 3) wet and dry, 4) pollution.
Longmuir

BCH 554 Radioisotope Techniques in Biology. *Preq.: BCH 451 or CI. 2(1-3) Sum.* Theory and application of radioisotope techniques used in biology. The different modes of radioactivity correlated with methods of measurement. Emphasis on use and limitations of various instruments and techniques and on their application to research problems.
Sisler

BCH 555 Plant Biochemistry. *Preq.: BCH 551 or equivalent. 3(3-0) S. Alt. yrs. ** The basic biochemistry of plants. Basic constituents of plants, their metabolic interrelationships and their regulation: cell wall structure, carbohydrates, proteins, nucleic acids, lipids, photosynthesis, respiration, secondary plant products, nitrogen metabolism, phytoalexins and plant hormones.
Sisler

*See department for specific year.

BCH (GN) 561 Biochemical and Microbial Genetics. *Preqs.: BCH 451 or 551, GN 411 or 505, MB 401 or equivalent. 3(3-0) F. Alt. yrs.* * A study of the development of the fields of biochemical and microbial genetics, emphasizing both techniques and concepts currently used in molecular research. Includes lectures and discussions of current research publications. Armstrong

BCH 590 Special Topics in Biochemistry. *Preq.: BCH 451 or equivalent. Credits arranged, Mar. 3 F,S,Sum.* The study of topics of special interest by small groups of students instructed by members of the faculty. Graduate Staff

FOR GRADUATES ONLY

BCH 651 Physical Biochemistry. *Preq.: BCH 551. 3(3-0) F. Alt. yrs.* * Structural and physical properties of biological macromolecules and the application of spectroscopic methods to their study. Knopp

BCH 652 Structures and Interactions of Biological Macromolecules. *Preqs.: BCH 551, CH 431 or equivalent. 3(3-0) F. Alt. yrs.* * Theory and interpretation of physical measurements related to structures and interactions of biological macromolecules, emphasizing hydrodynamic methods, thermodynamic methods, ligand interactions at equilibrium and conformational equilibria. Swaigood

BCH 653 Biochemistry of Hormone Action. *Preq.: BCH 551. 3(3-0) S. Alt. yrs.* * Well defined models of steroid and protein hormone action studied via lectures, assigned readings and discussions. Students add breadth to the course and depth to their own understanding by searching the literature and writing or lecturing about a particular hormone of their own choosing. Miller

BCH (GN) 658 Nucleic Acids: Structure and Function. *Preq.: BCH 657. 3(3-0) F. Alt. yrs.* * Structure-function relationships of nucleic acids and nucleic acid-protein complexes, including the physical biochemistry of nucleotides, polynucleotides, DNA, RNA and protein as they relate to the biological processes of replication, transcription and translation. Current techniques used to analyze nucleic acid structure and function. Maxwell

BCH (CH) 659 Natural Products. *3(3-0) F.* (See chemistry.)

BCH 691 Seminar in Biochemistry. *1(1-0) F,S.* Graduate Staff

BCH 692 Laboratory Rotations. *Preq.: BCH 451 or equivalent. 1(0-3) F,S,Sum.* Biochemistry students perform highly directed research in one or more laboratories of student's choice prior to beginning thesis research. Each laboratory experience lasts 5 weeks and given 1 hr. of credit. No more than 4 credits can be earned under BCH 692. Permission of instructor required. Graduate Staff

BCH 695 Special Topics in Biochemistry. *Preq.: Grad. standing in BCH. Credits Arranged. F,S,Sum.* Critical study of special problems and selected topics of current interest in biochemistry and related fields. Graduate Staff

BCH 699 Biochemical Research. *Credits Arranged, F,S,Sum.* Graduate Staff

Biological and Agricultural Engineering

GRADUATE FACULTY

Professor J. H. Ruff, Head

Professor R. S. Sowell, Graduate Administrator

Professors: C. F. Abrams, H. D. Bowen, F. J. Humenik, E. G. Humphries, W. H. Johnson, G. J. Kriz, W. F. McClure, R. P. Rohrbach, L. M. Safley Jr., R. W. Skaggs, R. E. Sneed, L. F. Stikeleather, C. W. Suggs, P. W. Westerman, D. H. Willits, J. H. Young; *Professors (USDA):* J. W. Dickens, T. B. Whitaker; *Extension Professor:* J. C. Barker; *Professors Emeriti:* D. H. Howells, F. J. Hassler, E. H. Wiser; *Associate Professors:* G. R. Baughman, C. G. Bowers Jr.; *Visiting Associate Professor:* M. D. Smolen; *Assistant Professors:* R. W. Bottcher, R. L. Hoffman; *Senior Researcher:* S. C. Mohapatra

ASSOCIATE MEMBERS OF THE DEPARTMENT

Professors: D. D. Hamann, A. E. Hassan, V. A. Jones, K. R. Swartzel; *Assistant Professor:* T. M. Losordo

The Department of Biological and Agricultural Engineering offers programs of study for the Master of Science, Doctor of Philosophy and Master of Biological and Agricultural Engineering degrees.

In the Master of Science program emphasis is placed on mathematics and theory as the unifying link between otherwise divergent fields of knowledge in the biological and physical sciences and as prerequisites to effective engineering advances in biological and agricultural areas. As the student acquires competence in the advanced methods of science, he or she applies knowledge by conducting an original research investigation and by writing and defending a thesis.

Study for the Doctor of Philosophy degree normally builds on the Master of Science program with additional formal study followed by a period of independent dissertation research.

Opportunities for graduate research are available in agricultural engineering (power and machinery, soil and water, structures and environment, food and process engineering, electrical and electronic systems, and forest mechanization), biological engineering (bioinstrumentation, biomechanics, human engineering, bioprocessing, food packaging and processing, biological systems modeling and aquaculture), environmental engineering (water table management, ground water management, animal waste management and non-point source pollution), and knowledge engineering (expert systems, robotics and machine vision).

Current departmental research projects available for graduate student participation include instrumentation to measure quality and composition of agricultural products, bioengineering properties as related to animal and human medicine, safety and health of agricultural workers, mechanization and automation of horticultural crop production (cucumbers, sweetpotatoes, blueberries and grapes), post-harvest processing and storage of agricultural commodities, envir-

onmental control of greenhouses, improved systems for field crop production, crop response to drainage, total water management for Coastal Plains and Tidewater Region soils, hydrologic/water quality modeling of sediment and chemical movement, optimum production efficiency of poultry and animal housing systems, animal waste as nutrient and energy resources, and expert systems and simulation modeling for management decisions.

For those interested primarily in a broadened background of engineering science and technology—without the thesis requirement—the Master of Biological and Agricultural Engineering program permits a wide selection from a variety of advanced courses. While this program is primarily for those intending to terminate graduate study at the master's level, a student may, with departmental approval, develop a plan of study under this program which leads to study for the doctorate.

Graduate students have access to modern well-equipped research facilities, computing facilities, instrumentation and measurement systems, electronics technical support, and mechanical and electronics shops.

SELECTED ADVANCED UNDERGRADUATE COURSES

BAE 411 Farm Power and Machinery. *Preqs.: BAE 211, CH 101, PY 211 or 221. 3(2-3) S.*

BAE 461 Analysis of Agricultural Systems. *Preqs.: MA 114 or 112, EB 212. 3(2-2) F.*

BAE 462 Functional Design of Field Machines. *Preq.: BAE 361; Coreq.: ST 361. 3(2-3) S.*

BAE (CHE) 465 Introduction to Biomedical Engineering. *Preqs.: MA 202 or 212 or PY 212 or 208. 3(3-0) S.*

BAE 471 Soil and Water Engineering. *Preqs.: BS 100, SSC 200, MAE 308. 4(3-2) F.*

BAE 481 Agricultural Structures and Environment. *Preqs.: BAE 342, MAE 314. 4(3-3) F.*

FOR GRADUATES AND ADVANCED UNDERGRADUATES

BAE 552 Instrumentation for Agricultural Research and Processing. *Preqs.: EE 331, MA 301. 2(1-3) F.* Theory and application of primary sensing elements and transducers. Generalized performance characteristics and the use of standards. Use of specialized measurement systems for agricultural research and processing including an introduction to correlation and power spectral density measurements. McClure

BAE (CE, MB) 570 Sanitary Microbiology. *3(2-3) S.* (See civil engineering.)

BAE (CE) 578 Agricultural Waste Management. *Preq.: Grad. or advanced undergrad. standing. 3(2-3) F. Alt. yrs.* A study of agricultural and associated processing wastes. Special laboratory techniques required for the characterization of these wastes emphasized. Principles and examples considered utilized to develop waste management and non-destructive waste utilization systems that are integral to the total operation. Safley

BAE (FS) 585 Food Rheology. *Preqs.: FS 331 or MAE 314. 3(2-3) F. Alt. yrs.* Principles and methods for measuring rheological properties. Theories of elastic, viscous, viscoelastic and viscoplastic behavior and relationships to food texture and commodity damage during harvest, handling and processing. Influence of time, composition and processing on rheological properties. Hamann

BAE 590 Special Problems. *Preq.: Sr. or grad. standing in biological and agricultural engineering. Credits Arranged.* Each student will select a subject on which to do research and write a technical report on the results. The individual may choose a subject pertaining to his or her particular interest in any area of study in biological and agricultural engineering. Graduate Staff

FOR GRADUATES ONLY

BAE 661 Analysis of Function and Design of Biological and Physical Systems. *Preq.: CI. 3(2-3) F. Alt. yrs.* Mathematical and analytical techniques and principles essential in the analysis and design of machines and systems which encompass both the biological and the physical domains and their interfaces. Analytical treatment of physical and biological systems and the functional analysis of machine components studied to bridge the gap between theories and applications. Control systems synthesis and design treated with emphasis on quantitative dynamic relations between elements and system response using transfer function and computer simulation techniques. Graduate Staff

BAE (SSC) 671 Theory of Drainage—Saturated Flow. *Preq.: MA 301. 3(3-0) F. Alt. yrs.* Physical concepts and properties of fluids and porous media discussed in relation to soil-water movement. The fundamental laws and equations governing saturated flow in porous media derived and discussed. Mathematical solutions of steady-state and transient flow equations analyzed to determine their applicability to drainage problems. Analogs and models of particular drainage problems considered. Skaggs

BAE (SSC) 674 Theory of Drainage—Unsaturated Flow. *Preq.: BAE 671 or equivalent. 3(3-0) S. Alt. yrs.* Forces involved and theories utilized in unsaturated flow of porous media discussed in relation to soil-water movement. Steady-state and transient unsaturated flow equations for horizontal and vertical moisture movement developed and solved. The solutions applied to present day laboratory and field technology. Molecular diffusion and hydrodynamic dispersion considered in light of current tracing techniques. Skaggs

BAE 690 Special Topics. *Preq.: Grad. standing. 1-4.* A study of topics in the special fields of interest of graduate students under the direction of the graduate faculty. Graduate Staff

BAE 695 Seminar. *Preq.: Grad. standing in BAE. 1(1-0) F,S.* Elaboration of the subject areas, techniques and methods peculiar to professional interest through presentations of personal and published works; opportunity for students to present and critically defend ideas, concepts and inferences. Discussions to point up analytical solutions and analogies between problems in biological and agricultural engineering and other technologies, and to present the relationship of biological and agricultural engineering to the socio-economic enterprise. Ruff

BAE 699 Research in Biological and Agricultural Engineering. *Preq.: Grad. standing in BAE. Credits Arranged.* Performance of a particular investigation of concern to biological and agricultural engineering. The study will begin with the selection of a problem and culminate with the presentation of a thesis. Graduate Staff

Biological Sciences

Professor C. F. Lytle, Teaching Coordinator

There is no separate graduate major in the biological sciences, but both Master of Science and Doctor of Philosophy degrees are offered in several life science departments and programs of the College of Agriculture and Life Sciences. Also, non-thesis Master of Life Sciences degrees are offered by several departments and programs for students who wish to emphasize course work in a graduate

program. Master of Life Sciences degrees may be appropriate for students who are already working or plan to work in a professional capacity in business, industry or government agencies rather than to continue to the doctorate. These degrees are not necessarily terminal, however, and successful students may be able to proceed to other advanced degrees.

Several interdisciplinary courses applicable to several graduate programs are offered by the Biological Sciences Interdepartmental Program.

SELECTED ADVANCED UNDERGRADUATE COURSE

BS 491 Seminar on Professional Development in Biological Sciences. *1(1-0) F.*

FOR GRADUATES AND ADVANCED UNDERGRADUATES

BS 510 Advanced Biology for Secondary Teachers. *Preq.: Two yrs. of college biology. 6(4-6) Sum.* A comprehensive review of important principles and concepts of biology for secondary teachers preparing to teach advanced placement biology. Contemporary topics in biology emphasized; extensive laboratory and field work are included. Lytle

BS 590 Special Problems in Biological Instrumentation. *Preq.: CI. 1-3 F,S.* Basic components of spectrophotometers including light sources, dispersing devices, detectors and read-out methods; theoretical and practical aspects of electron microscopy; basics of analog and digital computing methods and applications of computers to biological research; methods of separation and identification of bio-polymers; principles of measurement; the application of electronics in biological measuring and sensing devices; and human cytological techniques. Course consists of five-week modules (sections) devoted to specific types of instrumentation. Graduate Staff

FOR GRADUATES ONLY

BS 605 Biological Scanning Electron Microscopy. *Preq.: Grad. standing with some biological background. 2(1-2) S.* Theory and application of scanning electron microscopy, including specimen preparation, microscope alignment and operation, performance evaluation, interpretation of problems and darkroom technique. (Limited to 8 students with prior approval of instructor.) Mackenzie

BS 610 Biological Transmission Electron Microscopy. *Preq.: Grad. standing with some biological background. 3(2-3) F.* Theoretical and practical aspects of transmission electron microscopy, including microscope alignment and use, performance evaluation, interpretation of problems and darkroom techniques. (Limited to 8 students with prior approval of instructor.) Mackenzie

BS 611 Ultramicrotomy for Life Sciences. *Preqs.: BS 610, grad. standing. 2(1-4) S.* An intensive laboratory course covering sample preparative techniques for transmission electron microscopy, including tissue preparation, thick sectioning, staining and ultramicrotomy. (Limited to 8 students with prior approval of instructor.) Mackenzie

Biomathematics

GRADUATE FACULTY

Professor R. E. Stinner, Director

Professors: H. J. Gold, K. H. Pollock, H. R. van der Vaart; Adjunct Professor: M. W. Anderson; Professor Emeritus: R. J. Monroe; Associate Professors: S. P. Ellner, C. E. Smith

ASSOCIATE MEMBERS OF THE PROGRAM COMMITTEE

Professors: J. W. Bishir, T. Johnson, G. Namkoong, L. A. Real, H. E. Schaffer, J. F. Selgrade; *Assistant Professor:* G. G. Wilkerson; *Assistant Professor (USDA):* S. M. Schneider

Biomathematics is the development and application of mathematical methods for the study of biological systems. The focus is the modeling process, which is the matching of the biological and physical structure of the system being studied to the mathematical description.

Students pursuing degrees in biomathematics can choose to emphasize (1) the *development* of mathematical modeling methodology as opposed to the *application* of that methodology, (2) the mathematical sciences, by taking advantage of the diverse offering in statistics, mathematics, computer science and operations research, or (3) the biological sciences, by fashioning a program which takes advantage of the courses offered by individual biological science departments or interdepartmental programs such as ecology, physiology, nutrition, wildlife biology and toxicology.

Furthermore, work in biomathematics varies from the study of general biological theory (e.g., population dynamics, feedback regulation in enzyme systems) to specific applications (e.g., pollution of a specific river system). Most research has both elements. Finally, the modeling of biological systems often requires the scholarly resources of several disciplines and thus is characterized by interdisciplinary collaboration. The modeling serves to integrate the contributions of the various areas and to provide a means by which the collaborators communicate.

Applicants to the program are expected to have either a B.S. in biology with evidence of aptitude and interest in mathematics or a B.S. in a mathematical area with evidence of aptitude and interest in biology. All students are expected to have had advanced calculus, linear algebra and general biology. Deficiencies in these areas should be remedied during the first year.

The Biomathematics graduate program is administered as a division within the Department of Statistics, with associate faculty drawn from several other departments. Further information may be found in the description for the Department of Statistics. A brochure is available which describes the biomathematics degree requirements and research interests of the faculty.

FOR GRADUATES AND ADVANCED UNDERGRADUATES

BMA 567 Modeling of Biological Systems. *Preq.: MA 112. 4(3-2) F. Alt. yrs.* An introduction to quantitative modeling in biology. Use of Forrester diagrams, probabilistic and deterministic description of dynamic processes, development of model equations, simulation methods and criteria for model evaluation. Examination of current literature dealing with application of models and simulation in biology. Individual and class modeling projects. Ellner

BMA (MA, ST) 571 Biomathematics I. *Preq.: Advanced calculus, reasonable background in biology or CI. 3(3-0) F.* The role of theory construction and model building in the development of experimental science. The historical development of mathematical theories and models for the growth of one-species populations (logistic and off-shoots), including considerations of age distributions (matrix models, Leslie and Lopez; continuous theory, renewal equation). Some of the more elementary theories on the growth of organisms (von Bertalanffy and others; allometric theories; cultures grown in a chemostat). Mathematical

theories of two and more species systems (predator-prey, competition, symbiosis; leading up to present-day research), and discussion of some similar models for chemical kinetics. Much emphasis placed on scrutiny of the biological concepts as well as of the mathematical structure of the models in order to uncover both weak and strong points of the models discussed. Mathematical treatment of the differential equations in these models stresses qualitative and graphical aspects, as well as certain aspects of discretization. Difference equation models. van der Vaart

BMA (MA, ST) 572 Biomathematics II. *Preqs.: BMA 571, elementary probability theory. 3(3-0) S.* Continuation of topics of BMA 571. Some more advanced mathematical techniques concerning nonlinear differential equations of the types encountered in BMA 571: several concepts of stability, asymptotic directions, Liapunov functions; different time-scales. Comparison of deterministic and stochastic models for several biological problems including birth and death processes. Discussion of various other applications of mathematics to biology, some recent research. van der Vaart

BMA (OR, ST) 575 Decision Analytic Modeling. *4(3-2) F. Alt. yrs.* (See statistics.)

BMA 591 Special Topics. *Preq.: CI. Maximum 3. F,S,Sum.* Directed readings, problem sets, written and oral reports as dictated by need and interest of student; new 500-level courses during the developmental phase. Graduate Staff

FOR GRADUATES ONLY

BMA (MA, OR, ST) 610 Stochastic Modeling. *Preq.: BMA 572 or ST(MA) 542. 3(3-0) F. Alt. yrs.* Survey of modeling approaches and analysis methods for data from continuous state random processes. Emphasis on differential and difference equations with noisy input. Doob-Meyer decomposition of process into its signal and noise components. Examples from biological and physical sciences, and engineering. Student project. Smith

BMA (OR) 611 System Modeling Theory. *Preqs.: MA 405; MA 421 or ST 421; linear systems (e.g., BMA 572 or IE 522 or OR 531). 3(3-0) F. Alt. yrs.* System concepts and modeling processes. Objectives include the following: develop understanding of the modeling process; develop and improve skills in system modeling; provide basis for accessing research literature. Topics include: graph theory and system structure; system morphisms and representation of system dynamics; sensitivity and model validation; models in scientific theory compared with decision-related modeling. Examples from a broad spectrum of application areas. Gold

BMA 691 Advanced Special Topics. *Preq.: CI. 1-3 F,S,Sum.* Directed readings, problem sets, written and oral reports as dictated by need and interest of student; new 600-level courses during the development phase (currently includes courses in stochastic modeling and biophysical theory). Graduate Staff

BMA 694 Seminar. *Preq.: Grad. standing. 1(1-0) F,S.* Graduate students in biomathematics are expected to attend through most of their residence period. Graduate Staff

BMA 699 Research. *Credits Arranged. F,S,Sum.* Graduate Staff

Biotechnology

GRADUATE FACULTY

Professor H. E. Swaisgood, Chairman

Professors: P. F. Agris, F. B. Armstrong, G. C. Bewley, R. G. Carbonell, H.-m. Chang, W. J. Dobrogosz, P. B. Carter, C. K. Hall, B. Hammerberg, H. R.

Horton, T. W. Joyce, T. R. Klaenhammer, C. S. Levings, C. L. Markert, A. S. Michaels, W. L. Miller, R. L. Mott, D. F. Ollis, J. G. Scandalios, R. R. Sederoff, J. C. H. Shih, H. E. Swaisgood, C. S. Teng, E. C. Theil, W. F. Thompson; *Associate Professors*: H. V. Amerson, W. F. Boss, E. V. L. DeBuysscher, F. J. Fuller, T. Melton, R. M. Petters, S. L. Spiker, H. T. Stalker, K. G. Tatchell, S. Tonkonogy; *Associate Professor (USDA)*: P. E. Bishop; *Assistant Professors*: M. T. Andrews, R. S. Boston, E. F. Bowden, M. A. Conkling, S. E. Curtis, M. E. Daub, L. H. Frampton, P. K. Kilpatrick, R. J. Linderman, E. S. Maxwell, D. M. Miller, E. S. Miller, P. E. Orndorff, S. M. Peretti, M. A. Qureshi, R. M. Roe, R. M. Shuman, R. B. van Breemen; *Assistant Professor (USDA)*: P. H. Sisco

The Biotechnology Program includes faculty from seventeen departments in the Colleges of Agriculture and Life Sciences, Engineering, Forest Resources, Physical and Mathematical Sciences, and Veterinary Medicine. Graduate study leading to a Ph.D. minor in biotechnology may be taken by students who reside and conduct their research in one of the participating departments. To obtain a minor in biotechnology, the student must successfully complete at least two of the laboratory core courses selected from the list below and must conduct graduate thesis research in an area of biotechnology.

Research in biotechnology is focused in three main areas: recombinant DNA technology, bioprocessing/bioanalytical techniques, and *in vitro* culture techniques. The multidisciplinary nature of biotechnology means that a wide range of research topics and techniques are applicable, such as molecular level genetics and associated research in molecular biology, enzyme technology and protein engineering, bioprocessing using cells or enzymes, development of biosensors, hybridoma technology, cell culture techniques and embryo manipulation.

LIST OF APPROVED COURSES

ANS 606 Animal Biotechnology: Embryo Manipulation. *Preq.: ANS 502. 4(1-8) F. Alt. yrs.* Advanced laboratory course providing training and experience in mammalian embryo manipulation including techniques of super ovulation and embryo recovery, *in vitro* culture, parthenogenetic activation, *in vitro* fertilization, embryo aggregation, and DNA microinjection. Petters

CS(BO, GN, HS) 547 Cell and Tissue Techniques in Plant Breeding. *Preqs.: GN 505B and GN 506B or equivalent. 3(1-4) F. Alt. yrs.* Applications of tissue culture and cytogenetic techniques for plant improvement. Callus and suspension cultures, plant regeneration, *in vitro* selection, haploidy, polyploidy, aneuploidy, wide hybridization and embryo rescue. Practical lab experiences in tissue culture and cytogenetic techniques. Reed, Stalker

FS 504 Food Proteins and Enzymes. *Preq.: FS 402 or BCH 451. 3(2-3) F. Alt. yrs.* An advanced course in food chemistry with emphasis on proteins and enzymes of particular importance to foods. Protein interactions and their effect on the physical-chemical characteristics of a product discussed. Particular emphasis given to the preparation and kinetic properties of immobilized enzymes and their use as biochemical reactors in processing operations or as specific electrodes for analytical purposes. Swaisgood

GN 666 Laboratory in Molecular Genetics. *Preqs.: GN 505 or equivalent and CI. 4(2-6) S. Alt. yrs.* A laboratory course in modern techniques of molecular genetics for advanced students. Techniques include *in situ* hybridization, recombinant DNA methodology, and DNA sequencing. Enrollment limited to 12 students. Applications for a place in the course may be obtained from the department. Conkling

MB 660 Experimental Microbial Genetics. *Preqs.: BCH 561, GN 411, MB 401. 4(2-6) F.* Laboratory-oriented presentation of current methodologies and concepts in molecular microbial genetics and their application to strain construction, plasmid and phage manipulations, mutagenesis, cloning and genetic engineering of microorganisms. Melton

Botany

GRADUATE FACULTY

Professor E. D. Seneca, Head

Professors: C. E. Anderson, U. Blum, R. C. Fites, J. W. Hardin, R. L. Mott, W. F. Thompson, J. R. Troyer, C. G. Van Dyke, T. R. Wentworth, A. M. Witherspoon; *Professors (USDA):* W. W. Heck, H. E. Pattee, H. Seltmann; *Visiting Professor:* W. S. Chilton; *Professors Emeriti:* G. R. Noggle, H. T. Scofield, L. A. Whitford; *Associate Professors:* R. L. Beckmann Jr., W. F. Boss, J. M. Stucky, J. F. Thomas, T. E. Wynn; *Assistant Professors:* R. S. Boston, J. M. Burkholder, J. E. Mickle; *Adjunct Assistant Professor:* D. E. Blume

ASSOCIATE MEMBERS OF THE DEPARTMENT

Professors: A. W. Cooper, R. J. Downs, M. M. Goodman, E. C. Sisler, D. H. Timothy; *Professor (USDA):* S. C. Huber, D. E. Moreland, H. Seltmann; *Associate Professors:* H. V. Amerson, L. B. Crowder, R. L. Hoffman; *Assistant Professors (USDA):* J. M. Anderson, K. O. Burkey; *Associate Professor (USDA):* T. W. Rufty Jr.

The Department of Botany offers programs leading to the Master of Life Sciences (non-thesis), Master of Science and Doctor of Philosophy degrees.

Excellent physical facilities are available for instruction and research in all phases of the departmental program. The Phytotron (part of a two-unit controlled environment facility operated in collaboration with Duke University) offers opportunities for research in experimental taxonomy, ecology, morphology and plant physiology. The department supports a research program in plant cell and tissue culture and plant molecular biology. A herbarium supports studies in systematic botany, and is augmented by herbaria at nearby Duke University and the University of North Carolina at Chapel Hill. Field laboratories are available at the coast, in the Piedmont and in the mountains.

All graduate students will participate at least one semester during a degree program in the departmental instructional program. Graduate students are expected to attend and participate in the seminar program every semester they are in residence.

SELECTED ADVANCED UNDERGRADUATE COURSES

BO 400 Plant Diversity. *Preq.: BO 200. 4(3-3) F.*

BO 403 Systematic Botany. *Preq.: BS 100 or 105 or BO 200. 4(2-4) S.*

BO 413 Introductory Plant Anatomy. *Preq.: BO 200 or equivalent. 3(2-3) S.*

BO (ZO) 414 Cell Biology. *Preqs.: CH 223, PY 212, ZO 201 or 203. 3(3-0) S.*

BO 421 Plant Physiology. *Preqs.: BS 100 or BS 105 or BO 200 and one year of college chemistry. 4(3-3) F,S.*

BO 499 Independent Study in Botany. *Preqs.: At least eight hours of Botany, advanced standing and presentation of plan of work approved by a faculty member. 1-3 F,S.*

FOR GRADUATES AND ADVANCED UNDERGRADUATES

BO 510 Plant Anatomy. *Preq.: BO 200. 4(2-6) F.* A study of plant cells, ultrastructure, cell types, tissues, organs and patterns of growth and differentiation. Anderson

BO (CS, HS) 518 Biological Control of Weeds. *1(1-0) F.* (See crop science.)

BO 522 Advanced Morphology and Phylogeny of Seed Plants. *Preq.: BO 403. 4(3-3) F.* *Alt. yrs.* A comprehensive survey of the morphology and evolution of angiosperms and gymnosperms. Special emphasis is given to vegetative and reproductive morphology of fossil and living forms, and to their presumed evolutionary relationships. Hardin

BO 544 Plant Geography. *Preqs.: BO 403, BO (ZO) 360, GN 411 or equivalents. 3(3-0) S.* *Alt. yrs.* A course in descriptive and interpretive plant geography, synthesizing data from the fields of ecology, genetics, geography, paleobotany and taxonomy. Includes a survey of the present distribution of major vegetation types throughout the world, a discussion of the history and development of this present pattern of vegetation and a discussion of the principles and theories of plant geography. Mickle

BO (CS, GN, HS) 547 Cell and Tissue Techniques in Plant Breeding. *3(1-4) F.* *Alt. yrs.* (See crop science.)

BO 551 Advanced Plant Physiology I. *Preq.: BO 421 or equivalent. 3(3-0) F.* The first half of a two-semester sequence covering the field of plant physiology. Topics include cellular transport, water relations, mineral relations, vascular transport and temperature relations. Troyer

BO 552 Advanced Plant Physiology II. *Preqs.: BO 421 or equivalent and biochemistry. 3(3-0) S.* The second half of a two-semester sequence covering the field of plant physiology. Topics include respiration, photosynthesis, nitrogen metabolism, growth and development. Boss

BO 554 Laboratory in Advanced Plant Physiology II. *Preq. or coreq.: BO 552. 1(0-3) S.* Laboratory to accompany BO 552 Advanced Plant Physiology II Graduate Staff

BO (ZO) 560 Principles of Ecology. *Preq.: Three semesters of college level biology courses. 4(3-3) F.* A consideration of the principles of ecology at the graduate level. Each of the major subject areas of ecology developed in sufficient depth to provide a factual and philosophical framework for the understanding of ecology. Blum

BO 561 Physiological Ecology. *Preqs.: BO 421 and BO (ZO) 560 or equivalent. 4(3-3) S.* *Alt. yrs.* The plant community approached from a physiological standpoint. Emphasis placed on the individual in the community and how it responds to its immediate environment on short- and long-term bases. Blum

BO 565 Plant Community Ecology. *Preq.: BO (ZO) 560 or BO (ZO) 360 or equivalent. 4(3-3) F.* Consideration of the structure and function of terrestrial vascular plant communities, with emphasis on both classical and recent research. Topics include measurement and description of community properties, classification, ordination, vegetation pattern in relation to environment, ecological succession and a survey of the vegetation of North America. Wentworth

BO (BMA) 567 Modeling of Biological Systems. 4(3-2) F. (See biomathematics.)

BO (MB) 574 Phycology. *Freq.: BS 100 or BO 200. 3(1-4) S. Alt. yrs.* An introduction to the taxonomy, morphology, reproduction and ecological importance of organisms which may be included in the algae. Attention given to the local freshwater flow and the physiology of selected species as it relates to algal blooms, water quality and nutrient loading in aquatic habitats.
Graduate Staff

BO (MB, PP) 575 The Fungi. *Freq.: BO 200 or equivalent. 3(3-0) F.* An overview of the fungi within the framework of a survey of the major classes.
Van Dyke

BO (MB, PP) 576 The Fungi—Lab. *Coreq.: BO 575. 1(0-3) F.* Illustrative material of the fungal assemblages discussed in BO 575.
Van Dyke

BO 580 Plant Molecular Biology. *Preqs.: BCH 451, GN 411. 3(3-0) F.* Molecular analysis of plant growth and development. Molecular techniques and their application to understanding the control of gene expression in plants.
Boston

BO 590 Topical Problems. *Freq.: CI. 1-3 F, S.* Discussions and readings on problems of current interest in the fields of ecology, anatomy and morphology, taxonomy, plant physiology and cell biology. May be repeated with a change in topic for a maximum of six credits.
Graduate Staff

FOR GRADUATES ONLY

BO 612 Plant Morphogenesis. *Freq.: Six hrs. of botany equivalent to BO 400 and BO 421. 4(3-3) F. Alt. yrs.* A review and synthesis of the factors involved in the development of plant form. Tissue culture experiments demonstrate levels of control from the molecular to the whole organism.
Mott

BO 620 Advanced Taxonomy. *Freq.: BO 403. 4(2-6) S. Alt. yrs.* Taxonomic principles and techniques including rules of nomenclature, literature, biosystematic methods, monographic techniques and concepts of categories.
Stucky

BO (PP) 625 Advanced Mycology. 4(2-6) F. (See plant pathology.)

BO 631 Water Relations of Plants. *Freq.: BO 551 or equivalent. 3(3-0) S. Alt. yrs.* A discussion of the physiological water relations of plants with emphasis on theoretical principles and quantitative description.
Troyer

BO 633 Plant Growth and Development. *Preqs.: BO (ZO) 414 or BO 421, organic chemistry. 3(3-0) S.* An advanced course in plant physiology covering plant growth, development, differentiation, senescence and biological control mechanisms.
Fites

BO (ZO) 660 Advanced Topics in Ecology I. *Freq.: BO (ZO) 560. 3(3-0) S.* Subject matter in the major fields of ecology developed through seminars and lectures, and principles illustrated by laboratory exercises and field trips. Topics covered include microenvironment, population biology, community ecology, ecosystems and nutrient cycling.
Graduate Staff

BO 662 Applied Coastal Ecology. *Freq.: BO (ZO) 360 or BO (ZO) 560. 3(3-0) S. Alt. yrs.* Course covers the environmental factors, the vegetative communities, and man's influence on the ecology of the Coastal Plain of North Carolina. Emphasis placed on the coastal fringe (Outer Banks) and the problems involved in Coastal Zone Management. Course field- and problem-oriented and designed primarily for graduate students in environmentally oriented programs. Two field trips mandatory.
Seneca

BO 691 Botany Seminar. 1(1-0) F, S.

Graduate Staff

BO 693 Special Problems in Botany. *Credits Arranged.* Directed research in some phase of botany other than a thesis problem, but designed to provide experience and training in research. Graduate Staff

BO 699 Research. *Credits Arranged. F,S.* Original research preliminary to writing a master's thesis or a doctoral dissertation. Graduate Staff

Chemical Engineering

GRADUATE FACULTY

Professor G. W. Roberts, Head

Professor C. K. Hall, Graduate Administrator

Professors: R. G. Carbonell, P. S. Fedkiw, R. M. Felder, J. K. Ferrell, H. B. Hopfenberg, A. S. Michaels, D. F. Ollis, M. R. Overcash, E. P. Stahel; *Adjunct Professors:* F. O. Mixon, D. R. Squire; *Professors Emeriti:* D. B. Marsland, J. F. Seely, H. B. Smith, V. T. Stannett; *Associate Professors:* P. K. Kilpatrick, P. K. Lim, C. J. Setzer, S. Torquato, H. M. Winston; *Adjunct Associate Professor:* J. L. Williams; *Assistant Professors:* C. M. Balik, R. T. Chern, H. H. Lamb, S. W. Peretti

The Department of Chemical Engineering offers programs of advanced study leading to the Master of Science, Master of Chemical Engineering and Doctor of Philosophy degrees. Students enrolling for graduate study in the department normally have a bachelor's degree in chemical engineering, but programs can be arranged to accommodate students with degrees in applied mathematics, chemistry, physics and other branches of engineering.

The department occupies 50,000 square feet in the Riddick Engineering Laboratories. Within the building are laboratories for graduate research, fully staffed machine and electronics shops, and a well-equipped instrumental analysis laboratory. Several mini-computers and a large number of work stations and personal computers, connected to a local area network, provide outstanding programming and word processing capability.

Major research in the department is in the areas of biotechnology and polymer and membrane science and engineering. Other active research areas include heterogeneous and homogeneous catalysis, surface science, chemical reaction engineering, fluid dynamics, mass transfer in porous media, solid waste management, membrane separation techniques, batch process simulation and optimization, phase equilibrium thermodynamics, statistical thermodynamics, interfacial phenomena and electrochemical engineering.

The proximity of UNC-Chapel Hill, Duke University and the Research Triangle Park lends considerable support to departmental research programs. The Environmental Protection Agency, for example, has a major research facility in the Research Triangle Park. The department is headquarters for a major research center focused on industrial manufacturing improvements and the reduction of waste discharges to the environment.

A brochure describing in greater detail opportunities for graduate study and research in chemical engineering as well as available fellowships and assistantships may be obtained upon request from the graduate administrator.

SELECTED ADVANCED UNDERGRADUATE COURSES

CHE 425 Process System Analysis and Control. *Preq.: CHE 225. 3(3-0) F,S.*

CHE 446 Design and Analysis of Chemical Reactors. *Preq.: CHE 315; Coreq.: CHE 316. 3(3-0) F,S.*

CHE 451 Chemical Engineering Design. *Preqs.: CHE 421, 446. 3(2-2) F,S.*

CHE (BAE) 465 Introduction to Biomedical Engineering. *Preqs.: MA 202 or 212, PY 212 or 208. 3(3-0) F.*

FOR GRADUATES AND ADVANCED UNDERGRADUATES

CHE 511 Chemical Engineering Process Modeling. *Preqs.: CHE 311, CHE 312, MA 301. 3(3-0) F.* Applications of the methods of mathematical analysis to the formulation and solution of problems in transport phenomena, process dynamics and chemical reaction engineering. Fedkiw

CHE 513 Thermodynamics I. *Preqs.: CHE 315, 316. 3(3-0) F.* In-depth coverage of chemical engineering thermodynamics principles. Application of non-ideal fluid-phase chemical potentials to problems in phase and chemical reaction equilibria. Relations of molecular structure and intermolecular forces to macroscopic thermodynamic properties. Hall, Kilpatrick,

CHE 515 Transport Phenomena. *Preq.: CHE 311. 3(3-0) F.* A theoretical unified study of transport of momentum, energy and matter. The diffusional operations introduced in the light of the theory. Carbonell

CHE 516 Transport Phenomena II. *Preq.: CHE 515. 3(3-0) S.* Applications of the principles introduced in CHE 515. The applications include multiphase flow and sedimentation, non-Newtonian and porous media flows, transport through membranes and in electrochemical systems, and thermal instabilities. Carbonell

CHE 517 Chemical Reaction Engineering. *Preq.: CHE 446. 3(3-0) S.* Rates and mechanisms of homogeneous and heterogeneous reactions. Design, analysis and scale-up of batch and continuous chemical reactors. Felder, Stahel

CHE 521 Separation Processes. *Preq.: CHE 312. 3(3-0) S.* The theory and practice of staged multicomponent mass transfer operations and continuous rate processes. Problems unique to specific operations such as extractive and azeotropic distillation. Lamb, Stahel

CHE 525 Chemical Process Control. *Preq.: CHE 425. 3(3-0) F.* The application of control techniques to chemical process systems. Review of single-input, single-output control techniques, sampled data systems and Z-transform methods. Advanced control techniques including multivariable systems, inferential and adaptive control, deadtime control, and interaction analysis. Ferrell, Winston

CHE (OR) 527 Optimization of Engineering Processes. *Preqs.: CHE 451 or OR 501, FORTRAN programming. 3(3-0) F.* The formulation and solution of process optimization problems, with emphasis on nonlinear programming techniques. Computer implementation of optimization algorithms, on-line optimization, simulation methods and structuring of process models to increase computational efficiency. Felder

CHE 535 Engineering Economy in Air Pollution Control Systems. *Preqs.: MAE 409, CE 576 or equivalent first course. 3(3-2) F.* Design of equipment for the abatement of air pollution; estimation of capital cost and operating expenses; economic optimization under various kinds of tax laws. Marsland

CHE 543 Polymer Sciences and Technology. *Preqs.: CHE 223, CHE 316. 3(3-0) F.* Concepts and techniques for the polymerization of macromolecules. Structure, properties, and applications of commercially important polymers. Chern

CHE 551 Biochemical Engineering. *Preqs.: CHE 312, 446. 3(3-0) S.* Enzyme and microbial kinetics and reactor designs for processes involving enzymes and single and mixed cultures. Samples drawn from the full range of applications: food processing, single cell proteins, tissue culture and vaccines, monoclonal antibodies, recombinant DNA and hybridomas, artificial organs, biological waste treatment, and environmental processes. Guinnup, Ollis

CHE (TC) 569 Polymers, Surfactants and Colloidal Materials. *Preqs.: CHE 316, CH 223. 3(3-0) F.* Relationships between molecular structure and bulk properties of nonmetallic materials applied to commercial products and chemical engineering processes. Applications of surface and colloid chemistry and polymer science to product development and process improvement. Chern, Michaels

CHE (TC) 570 Radiation Chemistry and Technology of Polymeric Systems. *Preqs.: CH 221, 431. 3(3-0) S.* Principles and practice of isotope and electron beam radiation treatment. Applications of high energy radiation in polymer chemistry and technology, including the use of radiation to cross-link and degrade polymers. Similarities and differences between radiation polymerization and photopolymerization. Stannett, Williams

CHE 597 Chemical Engineering Projects. *Preq.: Grad. standing. 1-3 F,S.* Independent study of some phase of chemical engineering or a related field. Graduate Staff

CHE 598 Special Topics in Chemical Engineering. *Preq.: Grad. standing. 1-3 F,S.* Directed reading of the chemical engineering literature, introduction to research methodology, and lectures and seminar discussion on topics which vary from term to term. Graduate Staff

FOR GRADUATES ONLY

CHE 613 Thermodynamics II. *Preq.: CHE 513. 3(3-0) S.* Topics in chemical engineering thermodynamics. Perturbation theories, critical phenomena, multicomponent phase equilibria, supercritical extraction, irreversible thermodynamics and thermodynamics of macromolecules are representative topics. Hall, Kilpatrick

CHE 617 Advanced Chemical Reaction Engineering. *Preq.: CHE 517. 3(3-0) S.* Topics relating to the design, analysis and operation of homogeneous and heterogeneous chemical reactors. Stahel

CHE 619 Electrochemical Systems Analysis. *Preqs.: CHE 515, 517 or CI. 3(3-0) S. Alt. yrs.* Electrochemical thermodynamics, electrochemical kinetics and catalysis, coupled charge and material transport in an electric field and electrophoretic effects. Design and analysis of electrochemical reactors. Survey of electrochemical industry. Fedkiw

CHE 651 Separation Processes for Biological Materials. *Preq.: CHE 521 or CHE 551 or CI. 3(3-0) S.* Definition and engineering analysis of major bioseparation techniques useful in product isolation and purification. Topics discussed include solid-liquid separation, crystallization, filtration, extraction, chromatography, membrane processes, distillation, drying, combined operations and process economics. Ollis

CHE (TC) 669 Diffusion in Polymers. *Preq.: CHE 569 or CI. 2(2-0) S.* The theory of small molecule transport in polymers; applications of membrane transport processes in the chemical, polymer, textile, coatings and natural fiber industries. Chern, Hopfenberg

CHE (TC) 671 Special Topics in Polymer Science. *Preq.: CI. 1-3 F.* An intensive treatment of topics in polymer science and technology selected in accord with the state of the art. Chern, Stannett

CHE 695 Seminar. *1(1-0) F,S.* Weekly seminars on topics of current interest given by resident faculty members, graduate students and visiting lecturers. Graduate Staff

CHE 697 Advanced Chemical Engineering Projects. *Preq.: Grad. standing in CHE. 1-3 F,S. Sum.* Independent study of some phase of chemical engineering or a related field. Graduate Staff

CHE 699 Research. *Credits Arranged. F,S.* Individual research in chemical engineering. A report on this research is required as a graduate thesis. Graduate Staff

Chemistry

GRADUATE FACULTY

Professor K. W. Hanck, Head

Professor C. G. Moreland, Assistant Head for Graduate Studies

Professor M. L. Miles, Assistant Head for Business Affairs

Professor W. P. Tucker, Assistant Head for Undergraduate Studies

Professors: R. D. Bereman, L. H. Bowen, C. L. Bumgardner, H. H. Carmichael, D. L. Comins, L. D. Freedman, F. W. Getzen, F. C. Hentz Jr., Z Z. Hugus Jr., L. A. Jones, S. G. Levine, G. G. Long, A. F. Schreiner, L. B. Sims, E. O. Stejskal, G. H. Wahl Jr., M. H. Whangbo; *Professors Emeriti:* G. O. Doak, R. H. Loeppert, W. A. Reid, P. P. Sutton, R. C. White; *Associate Professors:* C. B. Boss, T. C. Caves, A. F. Coots, Y. Ebisuzaki, S. T. Purrington, W. L. Switzer, D. W. Wertz; *Associate Professor Emeritus:* T. M. Ward; *Assistant Professors:* E. F. Bowden, R. J. Linderman, M. G. Khaledi, R. B. van Breemen

The Department of Chemistry offers programs leading to the Master of Chemistry, Master of Science and Doctor of Philosophy degrees. Major fields of specialization are analytical, inorganic, organic and physical chemistry. A wide variety of advanced courses and a broad spectrum of research topics provide preparation for almost every type of position open to a chemist with an advanced degree.

A student entering graduate work in chemistry should have a bachelor's degree in chemistry or its equivalent. This includes the equivalent of one-year courses in general, organic, physical and analytical chemistry and a semester of inorganic chemistry. At least one year of college physics and two years of mathematics, including differential equations, are necessary. Students who fail to meet these requirements may in some cases be admitted on a provisional basis.

With a large graduate faculty and favorable graduate student to faculty ratio, the chemistry department emphasizes individual attention, small classes and personal collaboration on research with faculty members. Among the variety of active research projects available for thesis work are organic and inorganic synthesis, synthesis/characterization of semiconductors, structure and properties of organometallic compounds and transition metal complexes, stereochemistry, crystallography, kinetics, electrochemistry, micro and trace analysis, atomic and plasma spectroscopy, micro computer and statistical applications, quantum chemistry, and infrared, Raman, Mossbauer, nuclear magnetic resonance, nuclear quadrupole resonance, electron spin resonance, and natural and magnetic circular dichroism spectroscopy.

The department is equipped with standard instruments and apparatus for teaching and research. Many items of specialized equipment are available including recording spectrophotometers covering the range from far infrared to ultraviolet, nuclear magnetic resonance spectrometers, liquid chromatographs, gas chromatographs, high resolution mass spectrometer, atomic absorption spectrophotometers, electron spin resonance spectrometer, nuclear quadrupole resonance spectrometer, Mossbauer spectrometer, DC plasma spectrometer and X-ray diffractometer. Facilities for interfacing laboratory instruments and computers are available. The department's research activities are housed in a nine-story building and supported by glass, machine and electronic shops.

The department has available for qualified applicants teaching and research assistantships, as well as a number of fellowships.

SELECTED ADVANCED UNDERGRADUATE COURSES

CH 401 Systematic Inorganic Chemistry. *Coreq.: CH 431 or CH 331. 3(3-0) S.*

CH 411 Analytical Chemistry I. *Preq.: CH 434. 4(2-6) F.*

CH 413 Analytical Chemistry II. *Preq.: CH 411. 4(2-6) S.*

CH 428 Qualitative Organic Analysis. *Preq.: CH 223. 3(1-6) F,S.*

CH 431 Physical Chemistry I. *Preqs.: CH 107, MA 202, PY 203 or 208; Coreq.: MA 301. 3(2-1) F,S,Sum.*

CH 433 Physical Chemistry II. *Preqs.: CH 431 and MA 301. 3(2-1) F,S.*

CH 434 Physical Chemistry II Laboratory. *Preq.: CH 431; Coreq.: CH 433. 2(0-4) S.*

CH 435 Physical Chemistry III. *Preqs.: CH 431 and MA 301. 3(3-0) F.*

CH (TC) 461 Introduction to Fiber-Forming Polymers. *Preq.: CH 223. 3(3-0) F.*

CH 490 Chemical Preparations. *Preq.: Three yrs. of CH. 3(0-9) F,S.*

CH 493 Chemical Literature. *Preq.: Three yrs. of CH. 1(1-0) F.*

CH 499 Senior Research in Chemistry. *Preq.: Three yrs. of CH. Credits Arranged. 1-3 F,S,Sum.*

FOR GRADUATES AND ADVANCED UNDERGRADUATES

CH 501 Advanced Inorganic Chemistry I. *Preq.: CH 433. 3(3-0) F.* The major emphasis of this course on the complexes of the transition metals (3d, 4d and 5d). Topics include the structure, stability, synthesis and reaction mechanisms of these complexes. Included also is the consideration of organometallic compounds and of species containing metal-metal bonds.

CH 503 Advanced Inorganic Chemistry II. *Preq.: CH 501. 3(3-0) S.* This course, a continuation of CH 501, deals with the use of photochemical reactions as applied to inorganic complexes, metal cluster complexes and organometallic systems. Other topics treated at length are solid-state chemistry and bioinorganic chemistry. Discussion of structure, synthesis, energetics, reactions and applications presented. In addition, other topics of current research interest in inorganic chemistry briefly discussed.

CH 505 Physical Methods in Inorganic Chemistry. *Preqs.: Grad. standing and CH 501 or CI. 3(3-0) S.* The course describes the use of group, molecular orbital and ligand field theories for spectroscopy and bonding; measurement methodology and the significance of experimental parameters, including electronic, photoluminescence, photoelectron, vibrational spectroscopies, magnetic susceptibility, Mossbauer, esr, nmr, nqr and x-ray structure determinations.

CH (MAT) 507 Chemical Concepts in Materials Science and Engineering. *3(3-0) F.* (See materials science and engineering.)

CH 515 Chemical Instrumentation. *Preq.: CH 431; Coreq.: CH 411. 3(3-0) S.* Basic electronic components and circuits, the response of laboratory instruments, design and modification of typical electronic control and measurement systems. Emphasis placed on the transducers and control elements utilized in chemical research.

CH 517 Physical Methods of Elemental Trace Analysis. *Preq.: CH 315 or 331 or CI. 3(3-0) F.* The principles and applications of currently used methods of trace analysis presented. Designed for students with little or no experience in trace analysis but with a strong interest in or need for analytical data at the trace level. Topics include pulse polarography, potentiometry, UV-Vis spectrophotometry, atomic absorption, emission spectrometry, fluorescence, neutron activation analysis and spark source mass spectrometry.

CH 518 Trace Analysis Laboratory. *Coreq.: CH 517 or CI. 2(0-6) F.* The trace element content of samples determined by a variety of instrumental techniques including UV-Vis spectrophotometry, fluorescence, emission spectrometry, atomic absorption, pulse polarography and neutron activation analysis.

CH 521 Advanced Organic Chemistry I. *Preqs.: CH 223, 433 or 435. 3(3-0) F.* Structure stereochemistry and reactions of the various classes of hydrocarbons. The molecular orbital treatment of bonding and reactivity of alkenes, the conformational interpretation of cycloalkene and cycloalkene reactivity and the application of optical isomerism to the study of reaction mechanisms emphasized.

CH 523 Advanced Organic Chemistry II. *Preq.: CH 521. 3(3-0) S.* An introduction to acid-base theory and mechanistic organic chemistry as applied to synthetically useful organic reactions.

CH 525 Physical Methods in Organic Chemistry. *Preqs.: CH 223 and 433 or 435. 3(3-0) S.* Application of physical methods to the solution of structural problems in organic chemistry. Emphasis on spectral methods including infrared, ultraviolet, nuclear magnetic resonance, mass spectrometry, electron paramagnetic resonance, X-ray and electron diffraction and optical rotatory dispersion.

CH 530 Advanced Physical Chemistry. *Preq.: Grad. standing or CI. 3(3-0) F.* A survey of chemical thermodynamics and kinetics, with emphasis on reactions in the liquid phase. Problem solving an important part of the course. Designed to review and to expand on materials usually covered in a one-year undergraduate physical chemistry course.

CH 531 Chemical Thermodynamics I. *Preqs.: CH 433, MA 301. 3(3-0) F.* An extension of elementary principles to the treatment of ideal and real gases, ideal solutions, electrolytic solutions, galvanic cells, surface systems and irreversible processes. An introduction to statistical thermodynamics and the estimation of thermodynamic functions from spectroscopic data.

CH 533 Chemical Kinetics. *Preqs.: CH 433, MA 301. 3(3-0) S. Alt. yrs.* An intensive survey of the basic principles of chemical kinetics with emphasis on experimental and mathematical techniques, elements of the kinetic theory and theory of the transition state. Applications to gas reactions, reactions in solution and mechanism studies.

CH 535 Surface Phenomena. *Preqs.: CH 433, MA 301. 3(3-0) S. Alt. yrs.* An intensive survey of the topics of current interest in surface phenomena. Formulations of basic theories presented together with illustrations of their current applications.

CH 536 Chemical Spectroscopy. *Preq.: CH 435. 3(3-0) S. Alt. yrs.* Introduction to rotational, vibrational and electronic molecular spectroscopy from a quantum mechanical viewpoint. Emphasis on the elucidation of structure, bonding and excited state properties of organic and inorganic molecules.

CH 537 Quantum Chemistry. *Preqs.: MA 301, CH 435 or PY 407. 3(3-0) S.* The elements of wave mechanics applied to stationary energy states and time dependent phenomena. Applications of quantum theory to chemistry, particularly chemical bonds.

CH 539 Colloid Chemistry. *Preqs.: CH 220, 315 or 331, or CI. 3(2-3) S. Alt. yrs.* Theories, basic principles and fundamental concepts including preparation and behavior of sols, gels, emulsions, foams and aerosols and topics in areas of adsorption, Donnan equilibrium dialysis and small-particle dynamics. Laboratory includes independent project studies in specialized areas.

CH (MAT, TC) 562 Physical Chemistry of High Polymers—Bulk Properties. *3(3-0) F.* (See textile chemistry.)

CH 595 Special Topics in Chemistry. *Preq.: CI. 1-3 F, S.* Detailed study of a particular problem or technique pertaining to chemistry.

FOR GRADUATES ONLY

CH 611 Analytical Spectroscopy. *Preq.: CH 413 or 433. 3(3-0) S. Alt. yrs.* Presentation of the quantitative laws of spectroscopic analysis and discussion of deviations. Discussion of experimental methods for spectroscopic observation.

CH 613 Electrochemistry. *Preq.: CH 433. 3(3-0) S. Alt. yrs.* The thermodynamics and kinetics of electrode reactions presented as well as the experimental methods for studying them. Particular emphasis on the measurement of standard potential and establishing the number of electrons transferred. Applications of electrochemistry in the production/storage of energy and in chemical analysis are discussed.

CH 625 Organic Reaction Mechanisms. *Preqs.: CH 523, CH 433. 3(3-0) S.* A study of the effects of structure and substituents on the direction and rates of organic reactions.

CH 627 Chemistry of Metal-Organic Compounds. *Preq.: CH 521. 3(3-0) F. Alt. yrs.* Preparation, properties and reactions of compounds containing the carbon-metal bond with a brief description of their uses.

CH 631 Chemical Thermodynamics II. *Preq.: CH 531. 3(3-0) S. Alt. yrs.* Statistical interpretation of thermodynamics; use of partition functions; introduction to quantum statistics; application of statistical mechanics to chemical problems, including calculation of thermodynamic properties, equilibria and rate processes.

CH (BCH) 659 Natural Products. *Preqs.: CH 523, 525 or CI. 3(3-0) F.* Illustrative studies of structure determination, synthesis and biosynthesis of natural substances. Modern physical methods and fundamental chemical concepts stressed. Examples chosen from such classes as alkaloids, terpenes, steroids and antibiotics.

CH (MAT, TC) 662 Physical Chemistry of High Polymers—Solution Properties. *3(3-0) S. Alt. yrs. (See textile chemistry.)*

CH 691 Seminar. *Preq.: Grad. standing in CH. 1(1-0) F,S.* Scientific articles, progress reports on research and special problems of interest to chemists reviewed and discussed.

CH 695 Advanced Topics in Chemistry. *Preq.: CI. Maximum 3 F,S.* Critical study in one of the branches of chemistry.

CH 697 Advanced Chemistry Projects. *Preq.: Grad. standing in CH. 1-3. F,S,Sum.* Independent literature study of a current subject in chemistry. A critical review paper of the selected subject must be written.

CH 699 Chemical Research. *Preq.: Grad. standing in CH. Credits Arranged. F,S.* Special problems that furnish material for a thesis. A maximum of six semester credits allowed toward a master's degree; no limitation on credits in the doctoral program.

Civil Engineering

GRADUATE FACULTY

Professor E. D. Brill Jr., Head

Professor H. E. Wahls, Associate Head, Graduate Program

Professors: P. D. Cribbins, R. A. Douglas, J. F. Ely, J. S. Fisher, W. S. Galler, A. K. Gupta, K. S. Havner, Y. Horie, J. W. Horn, D. W. Johnston, N. P. Khosla, P. H. McDonald, C. C. Tung, P. Z. Zia; *Adjunct Professor:* R. C. Heath; *Professors Emeriti:* M. Amein, W. F. Babcock, R. E. Fadum, C. L. Heimbach, A.-A. I. Kashef, S. W. Nunnally, C. Smallwood Jr., M. E. Uyanik; *Associate Professors:* S. H. Ahmad, W. L. Bingham, R. H. Borden, A. C. Chao, E. D. Gurley, P. C. Lambe, H. R. Malcom Jr., V. C. Matzen, J. M. Nau, M. F. Overton, M. S. Rahman, W. J. Rasdorf, J. C. Smith, J. R. Stone; *Adjunct Associate Professor:* J. E. Tidwell; *Assistant Professors:* R. C. Borden, F. Farid, R. R. Rust, A. E. Schultz

INTERINSTITUTIONAL ADJUNCT GRADUATE FACULTY

S.-Y. Chang, L. E. King, H. D. Robertson, J. S. Wu

The Department of Civil Engineering offers programs of study leading to the Master of Civil Engineering, Master of Science and Doctor of Philosophy degrees. Students may major in construction engineering, geotechnical engi-

neering, public works engineering, structural engineering and mechanics, transportation engineering, coastal and ocean engineering, or sanitary and water resources engineering.

The Master of Civil Engineering degree is a non-thesis program emphasizing engineering design and practice. The program of study must include a minimum of three credit hours of independent study with a final written report. The Master of Science degree requires a thesis for which no more than six semester hours of credit may be used to satisfy the minimum degree requirements. For both degrees, the major and supporting areas of study may be selected from specialty areas within the Department of Civil Engineering. Both degrees require a final oral examination.

For the doctoral program, there are no definite requirements in credit hours. The coursework usually requires about one year of full-time study beyond the master's degree. The major element of the doctoral program is the dissertation, which reports an original investigation that represents a significant contribution to knowledge.

The faculty is engaged in broad research areas including deterministic and probabilistic structural theories and mechanics, fundamental behavior of soils and structures, computer-aided design, artificial intelligence, highway safety, land use and urban planning, hydraulics and hydrology, coastal processes, materials, construction engineering and management, waste disposal and pollution control. Many of the investigations are sponsored by industries and federal and state agencies including the continuing cooperative highway research program.

The department cooperates with other University divisions in joint programs. The department, in collaboration with the Department of Political Science and Public Administration, offers a program in public works engineering administration leading to the Master of Civil Engineering with a co-major in public affairs. Qualified students may schedule courses in this department and in the Department of City and Regional Planning at the University of North Carolina at Chapel Hill to receive a dual degree, a Master of Science with a major in transportation engineering and a Master of Regional Planning. Multidisciplinary study and research programs are also available through the North Carolina Institute for Transportation Research and Education, Water Resources Research Institute and the North Carolina Sea Grant Program.

Students in other disciplines may develop minor areas of study within the framework of departmental course offerings. In particular, courses of instruction in stream sanitation and industrial waste disposal provide the types of training in pollution control often in demand by industry.

Brochures and supplementary information on graduate study, research and assistantships and fellowships are available upon request from the graduate administrator of the Department of Civil Engineering. For applicants without a degree from a U.S. institution, GRE scores are required to expedite consideration for admission and financial aid. This requirement may be waived upon written request for applicants with an exceptional scholastic record.

SELECTED ADVANCED UNDERGRADUATE COURSES

CE 406 Transportation Systems Engineering. *Preq.: CE 305; Coreqs.: IE 311, CE 375. 3(3-0) F,S.*

- CE 425 Intermediate Structural Analysis.** *Preq.: CE 325. 3(3-0) F, S.*
- CE 426 Structural Steel Design.** *Preq.: CE 325. 3(3-0) F, S.*
- CE 428 Structural Design in Wood.** *Preq.: CE 325. 3(2-2) F.*
- CE 443 Seepage, Earth Embankments and Retaining Structures.** *Preq.: CE 342. 3(3-0) F, S.*
- CE 463 Cost Analysis and Control.** *Preq.: CE 365. 3(2-3) F, S.*
- CE 464 Legal Aspects of Contracting.** *Preq.: Sr. standing. 3(3-0) F, S.*
- CE 466 Building Construction Engineering.** *Preqs.: CE 327, 365; Coreq.: CE 426. 3(2-2) F, S.*
- CE 487 Introduction to Coastal and Ocean Engineering.** *Preqs.: CE 382, sr. standing. 3(3-0) S.*
- CE 484 Water Supply and Waste Water Systems.** *Preq.: CE 383. 3(3-0) F, S.*

FOR GRADUATES AND ADVANCED UNDERGRADUATES

- CE 501 Transportation Systems Analysis.** *Preq.: CE 406. 3(3-0) F.* Application of systems analysis to multi-modal transportation studies. Analysis, planning and design of transportation facilities for both the public and private sectors. Planning discussed from both short-run and long-run perspectives.
Stone
- CE 502 Transportation Operations.** *Preq.: CE 406. 3(3-0) F.* The analysis of traffic and transportation engineering operations.
Graduate Staff
- CE 503 Transportation Design.** *Preq.: CE 406. 3(2-2) S.* The geometric elements of traffic and transportation engineering design.
Cribbins, Horn
- CE 504 Water Transportation.** *Preq.: CE 305. 3(3-0) S Alt. yrs.* The planning, design and operation of waterways, ports, harbors and related marine facilities. Development of analytical techniques for evaluating maritime commodity flows and infrastructure feasibility.
Cribbins
- CE 507 Airphoto Analysis I.** *Preq.: Sr. standing. 3(2-3) S.* Principles and concepts for engineering evaluation of aerial photographs, including analysis of soils and surface drainage characteristics.
Wahls
- CE 508 Public Works Engineering—Operations and Administration.** *Preq.: CE 406 or CE 484. 3(3-0) F.* Organization, operational management and engineering responsibilities of a municipal and/or public works engineering department.
Horn
- CE 509 Public Works Engineering—Analysis and Design.** *Preq.: CE 508. 3(1-4) S.* Modular design-oriented public works topics, including implication, policies, illustrations and case studies.
Horn
- CE 510 Airport Planning and Design.** *Preq.: CE 305. 3(3-0) F.* The analysis, planning and design of air transportation facilities.
Cribbins
- CE 511, 512 Continuum Mechanics I, II.** *Preqs.: CE 313 or MAE 314, CE 382 or MAE 308, MAE 301, MA 405. (511) 3(3-0) F; (512) 3(3-0) S. Alt. yrs.* The concepts of stress and strain presented in generalized tensor form. Emphasis placed on the discussion and relative comparisons of the analytical models for elastic, plastic, fluid, viscoelastic, granular and porous media. The underlying thermodynamic principles presented, the associated boundary value problems formulated and selected examples used to illustrate the theory.
McDonald

CE 513 Theory of Elasticity I. *Preq.: CE 313 or MAE 314. 3(3-0) S.* The fundamental equations governing the behavior of an elastic solid developed in various curvilinear coordinate systems. Plane problems, as well as the St. Venant problem of bending, torsion and extension of bars covered. Displacement fields, stress fields, Airy and complex stress functions among the methods used to obtain solutions. Douglas, Gurley, Horie

CE 514 Stress Waves. *Preqs.: MA 301; CE 313 or PY 411 or MA 401 or MEA 351. 3(3-0) F. Alt. yrs.* Introduction to the theory of stress waves in solids. Origins and nature of longitudinal transverse and surface waves originating at an impact site or from other transient disturbances. Determination of stresses, particle velocities, wave velocities. Introduction to wave interaction with other waves and with boundaries and dissimilar materials. Introduction to modern instrumentation and seismic refraction exploration. Douglas

CE 521 Advanced Strength of Materials. *Preq.: CE 313 or MAE 314. 3(3-0) F.* Stresses and strains at a point: rosette analysis; strength theories, stress concentration and fatigue; torsion and unsymmetrical bending of open and closed sections; inelastic, composite and curved beams; energy methods; shear deflections; and membrane stresses in shells. Graduate Staff

CE 522 Elastic Stability. *Preqs.: CE 521, MA 301, 405. 3(3-0) S.* A study of elastic and plastic stability. The stability criterion as a determinant. The energy method and the theorem of stationary potential energy. The solution of buckling problems by finite differences and the calculus of variations. The application of successive approximations to stability problems. Graduate Staff

CE 524 Analysis and Design of Masonry Structures. *Coreq.: CE 427. 3(3-0) F. Alt. yrs.* Theory and design of masonry arches, culverts, dams, foundations and masonry walls subjected to lateral loads. Graduate Staff

CE 525 Matrix Structural Analysis. *Preq.: CE 425. 3(3-0) F.* Direct formulation of the banded system stiffness matrix and loading vectors for a first order Displacement Method analysis of two- and three-dimensional structural frames, trusses and grids; analysis by substructures; effects of prestrain, temperature, support settlements, shear deformations and joint deformations; second order analysis; computer applications using existing computer programs. Smith

CE 526 Finite Element Methods for Civil Engineering. *Preqs.: CE 425 and prior programming knowledge. 3(3-0) S.* A basic course in finite element method for civil engineering. Development, theory and formulation of various finite elements. On-hand finite element computer programming. On-hand finite element analysis of civil engineering problems, such as dam structures, hyperbolic cooling towers, slabs and soil-structure interaction problems. Gupta

CE 527 Analysis and Design of Structures for Dynamic Loads. *Preq. or coreq.: CE 525. 3(3-0) F.* Analysis and design of single and multi-degree-of-freedom structures subjected to various types of excitations and initial conditions. Computational aspects of dynamic analysis. Introduction to nonlinear analysis techniques and to approximate methods of analysis. Consideration of strong motion earthquakes. Study of earthquake regulations in building codes. Matzen, Nau

CE 531 Structural Models. *Preq.: CE 427. 3(2-3) F.* Dimensional analysis and structural similitude, indirect and direct models, model materials and experimental techniques, individual project in structural model analysis. Bingham, Matzen

CE 534 Plastic Analysis and Design. *Preq.: CE 427. 3(3-0) S.* Theory of plastic behavior of steel structures; concept of design for ultimate load and the use of load factors. Analysis and design of components of steel frames including bracings and connections. Smith

CE 536 Theory and Design of Prestressed Concrete. *Coreq.: CE 427. 3(3-0) F.* The principles and concepts of design in prestressed concrete including elastic and ultimate strength analyses for flexure, shear, torsion, bond and deflection. Principles of concordancy and linear transformation for indeterminate prestressed structures. Application of prestressing to tanks and shells.

Ahmad, Zia

CE (MEA) 541 Gravity Wave Theory I. *3(3-0) S.* (See marine, earth and atmospheric sciences.)

CE 544 Foundation Engineering. *Preq.: CE 342. 3(3-0) S.* Subsoil investigations; excavations; design of sheeting and bracing systems; control of water; footing, grillage and pile foundations; caisson and cofferdam methods of construction.

R. H. Borden, Lambe

CE 548 Engineering Properties of Soils I. *Preq.: CE 342. 3(2-3) F.* The study of soil properties that are significant in earthwork engineering, including properties of soil solids, basic physiochemical concepts, classification, identification, plasticity; permeability, capillarity and stabilization. Laboratory work includes classification, permeability and compaction tests.

R. H. Borden, Lambe

CE 551 Theory of Concrete Mixtures. *Preq.: CE 332. 3(3-0) F.* A study in depth of the theory of portland cement concrete mixtures including types and properties of portland special cements; chemical reactions; brief examination of history of mixture design; detailed study of current design methods; properties of fresh and hardened concretes; strength-age-curing relationships; durability; admixtures; special concretes; production and quality control.

Graduate Staff

CE 553 Asphalt and Bituminous Materials. *Preq.: CE 332. 3(2-3) S.* A study in depth of properties of asphalts and tars for use in waterproofing and bituminous materials, and theories of design of bituminous mixtures for construction and paving uses including types and properties of asphalt cements, cutbacks, emulsions, blown asphalts and tars; brief examination of historical developments; detailed study of properties and design of bituminous mixtures; and current research. Laboratory work includes standard tests on asphalts, tars and road oils; design, manufacture and testing of trial batches; and current research techniques.

Khosla

CE 555 Highway and Airport Pavement Design. *Preq.: CE 406 or 443. 3(2-3) F.* Theoretical analysis and design of highway and airport pavements with critical evaluation of current design practices.

Khosla

CE 561 Construction Planning and Scheduling. *Preq.: CE 463. 3(3-0) F.* Construction project planning, scheduling and control utilizing network methods. Both manual and computer techniques will be applied. Introduction to other quantitative management methods in construction. Utilizing the principles developed, students bid, plan, schedule and manage a construction project under competitive conditions in a computer-simulated environment.

Graduate Staff

CE 562 Construction Productivity. *Preq.: CE 463 or equivalent. 3(3-0) F.* Methods of collecting, assembling and analyzing construction productivity data in order to increase construction productivity. Applications of methods improvement techniques such as time-lapse photography, flow charts, process charts and time standards to the improvement of construction productivity. Safety and human factors in construction and their relation to construction productivity.

Graduate Staff

CE 566 Building Construction Systems. *Preq.: CE 466 or CE 427 or grad. standing in ARC. 3(3-0) S.* Construction engineering of conventional and industrialized building systems. Emphasis in the areas of structural systems utilizing cast-in-place concrete, precast concrete, prestressed concrete, structural steel, cold-formed steel, masonry, timber, composite and mixed materials. Topics include mechanisms for resisting and transmitting loads, detailing, fabrication, transportation, erection, stability, shoring, quality control and integration of service systems.

Johnston

CE (BAE, MB) 570 Sanitary Microbiology. *Preq.: MB 401 or equivalent. 3(2-3) S.* Fundamental aspects of microbiology and biochemistry presented and related to problems of stream pollution, refuse disposal and biological treatment. Laboratory exercises present basic microbiological techniques and illustrate from a chemical viewpoint some of the basic microbial aspects of waste disposal. Chao

CE 571 Theory of Water and Waste Treatment. *Preq.: Grad. standing. 3(3-0) F.* Study of the basic physical and chemical processes underlying water and waste treatment, including mass transfer, equilibria, and kinetics. Galler

CE 572 Design of Water and Wastewater Facilities. *Preq.: CE 571. 3(3-0) S.* Theory and design of water and wastewater treatment plants. Chao

CE 573 Unit Operations and Processes in Waste Treatment. *Preq.: CE 486; Coreq.: CE 571. 3(1-6) F.* Unit operations and processes in water and wastes engineering, including sedimentation, thickening, chemical coagulation, vacuum filtration, carbon adsorption, biological treatment, and special projects. Chao, Galler

CE 575 Civil Engineering Systems. *Preq.: MA 405. 3(3-0) S.* An examination of civil engineering systems and their design optimization. The systems to be studied include water resources engineering, structural engineering, transportation engineering and construction. Galler

CE (BAE) 578 Agricultural Waste Management. *3(2-3) F.* (See biological and agricultural engineering.)

CE 580 Flow in Open Channels. *Preq.: CE 382. 3(3-0) F.* The theory and applications of flow in open channels, including dimensional analysis, momentum-energy principle, gradually varied flow, high-velocity flow, energy dissipators, spillways, waves, channel transitions and model studies. Graduate Staff

CE 582 Coastal Hydrodynamics. *Preq.: CE 382 or equivalent. 3(3-0) F.* Surface gravity waves, solitary waves, longwaves, impulsively generated waves, flow in inlets and estuaries, storm surge, wave refraction and diffraction, harbor oscillations. Overton

CE 583 Engineering Aspects of Coastal Processes. *Preq.: CE 382 or equivalent; Coreq.: MEA (CE) 541. 3(3-0) S.* Coastal environment, engineering aspects of the mechanics of sediment movement, littoral drift, beach profiles, beach stability, meteorological effects, tidal inlets, inlet stability, shoaling, deltas, beach nourishment, mixing processes, pollution of coastal waters, interaction between shore processes and man-made structures, case studies. Fisher

CE 584 Hydraulics of Ground Water. *Preq.: CE 382. 3(3-0) F.* Introduction to ground water hydraulics and hydrology. Hydrologic cycle, basic ground water hydraulics, numerical solution of governing equations, ground water hydrology of North Carolina, well design and construction, flow new development, and ground water contamination sources. R. C. Borden

CE 585 Urban Stormwater Management. *Preq.: CE 383. 3(3-0) F.* Studies of stormwater management in urban areas emphasizing quantitative problems in flooding, sedimentation and water quality. Review and extension of design concepts involving channels and impoundments. Survey of hydrographic formation techniques and examination of common hydrologic models. Case studies of urbanizing watersheds. Malcom

CE 586 Engineering Hydrology. *Preq.: CE 383. 3(3-0) F. Alt. yrs.* A study of hydrologic principles underlying procedures for surface water modeling; applications of common hydrologic models to actual watersheds. Malcom

CE 589 Special Topics in Civil Engineering. *3(3-0) F, S.* New or special course on recent developments in some phase of civil engineering. Specific topics and prerequisites are identified for each section and will vary from term to term. Graduate Staff

CE 591, 592 Civil Engineering Seminar. *11(1-0) F, S.* Discussions and reports of subjects in civil engineering and allied fields. Graduate Staff

CE 598 Civil Engineering Projects. *1-6 F, S.* Research- or design-oriented independent study and investigation of a specific civil engineering topic, which culminates in a final written report. A minimum of three credits required for the MCE degree. Graduate Staff

FOR GRADUATES ONLY

CE 601 Transportation Planning. *Preq.: CE 502. 3(3-0) F. Alt. yrs.* The planning, administration and evaluation of various transportation engineering facilities. Cribbins

CE 603 Advanced Airport Systems Design. *Preq.: CE 510. 3(3-0) S. Alt. yrs.* The planning, design and operation of the components of the U. S. air transportation system with special emphasis on the forecasting and analysis techniques used at major airports. Cribbins

CE 604 Urban Transportation Planning. *Preq.: CE 501. 3(3-0) S. Alt. yrs.* Planning and design of urban transportation systems as related to comprehensive urban planning; principles of land use planning, urban thoroughfare planning and regional planning. Graduate Staff

CE 614 Plasticity and Limit Analysis. *Preq.: CE 513 or 521. 3(3-0) S. Alt. yrs.* Stress-strain rate relationships and theorems of limit analysis and shakedown in plastic solids. Application to collapse load calculations in arches, rings, plates and axisymmetric shells. Introduction to slip-line field theory of plane plastic flow and to dynamic limit analysis. Havner

CE 615 Finite Deformation of Materials I. *Preqs.: CE 511 or 513, MA 512. 3(3-0) F. Alt. yrs.* Application of the principles of classical continuum mechanics to the study of large deformation of solid materials. Finite strain geometry and kinematics, work-conjugate stress and stress-rate measures, rotating reference frames, local balance laws and jump conditions. Constitutive equations of nonlinearly elastic and inelastic behavior, general theorems for rate-type boundary value problems, conditions for bifurcation of solution. Havner

CE 616 Finite Deformation of Materials II. *Preq.: CE 615. 3(3-0) S. Alt. yrs.* Continuation of the study of finite deformation of materials, with emphasis on metal plasticity. Analytical connections between constituent and aggregate behavior in heterogeneous solids. Kinematics of crystals, theories of slip-system hardening, existence of plastic potentials. Physical and mathematical justification for the normality postulate in polycrystalline plasticity. Considerations of experiment, analysis of various mechanical tests at finite strain. Havner

CE 623 Theory of Plates and Shells. *Preq.: CE 513 or CE 521. 3(3-0) F.* Small and large deflection theories of thin plates; membrane analysis of shells. Various methods of analysis are discussed and illustrated by problems of practical interest. Gupta

CE 625, 626 Advanced Structural Design I, II. *Preqs.: (625): CE 427, CE 525; (626) CE 427; Coreqs.: (626) CE 525, 526. (625) 3(3-0) S. (626) 3(2-3) F. Alt. yrs.* Complete structural design of a variety of projects including comparative study of alternative solutions. Discussions of long span structural systems. Graduate Staff

CE 627 Advanced Analysis and Design of Structures for Dynamic Loads. *Preq.: CE 527. 3(3-0) F. Alt. yrs.* Consideration of the following advanced topics in the analysis and design of structures for dynamic loads: eigenvalue routines and numerical integration techniques; response analysis through the frequency domain; investigation of damping; variational formulation of the equations of motion; analysis and design of continuous systems; approximate methods of analysis; and special topics. Matzen

CE 628 Earthquake Structural Engineering. *Preq.: CE 527. 3(3-0) S.* Study of the effects of earthquakes on structures and of the design of structures to resist earthquake motions; earthquake mechanisms and ground motions; response of structures to earthquake motions; behavior of materials, structural elements and assemblages subjected to earthquakes; principles of earthquake-resistant design practice; soil-structure interactions; and special topics. Gupta, Nau

CE 632 Probabilistic Methods of Structural Engineering. *Preqs.: CE 525 and MA 421. 3(3-0) F. Alt. yrs.* Application of probability theory and stochastic processes to the study of safety of structures. Fundamentals of probability theory and stochastic processes; probabilistic modelings of structural loadings, material properties and risk. Reliability analysis of structures; reliability-based design criteria. Random vibration of simple structures; safety analysis of structures under dynamic loads. Tung

CE 635 Advanced Theory of Concrete Structures. *Preq.: CE 536. 3(3-0) S.* Inelastic theory of structural concrete members under flexure, axial load, combined flexure and axial compression, shear and torsion. Yield line theory of slabs. Limit analysis of beams and frames of reinforced and prestressed concrete. Ahmad, Zia

CE 641, 642 Advanced Soil Mechanics. *Preq.: Grad. standing. 3(3-0) F,S.* Theories of soil mechanics; failure conditions; mechanical interaction between solids and water, and problems in elasticity and plasticity pertaining to earthwork engineering. Wahls

CE 644 Ground Water Contaminant Transport. *Preq.: CE 534. 3(3-0) F.* Introduction to the movement and attenuation of contaminants in the subsurface. Topics include common contaminant sources; advection and dispersion; numerical modeling of contaminant transport; chemical and biological processes in the subsurface; and ground water restoration technology. R. C. Borden

CE 646 Dynamics of Soils and Foundations. *Preq.: CE 641. 3(3-0) S. Alt. yrs.* The application of vibration and wave propagation theories to soil media; the review of existing experimental data and empirical procedures for analysis of foundation vibrations, the prediction of soil responses to impulse loads, dynamic properties of soils and methods for their determination, design procedures for foundation subjected to dynamic forces. Rahman, Wahls

CE 665 Construction Equipment Systems. *Preq.: CE 561 or CE 562 or equivalent. 3(3-0) S.* Analysis of earthmoving and other heavy construction processes as systems in order to optimize the selection and employment of construction equipment. Considerations in system design, cost and productivity estimation, operational procedures, safety, and maintenance. Computer applications utilizing analytical and simulation techniques. Graduate Staff

CE 671 Advanced Water Management Systems. *Preqs.: CE 375, CE 571. 3(3-0) S. Alt. yrs.* The application of systems analysis methods to the design, analysis and management of water and waste systems. Galler

CE 672 Advanced Water and Waste Treatment: Principles and Design. *Preq.: CE 571. 4(3-3) S.* Theory and design of physiochemical processes used to control phosphorus, nitrogen, trace metals and toxic organic substances in water. Galler

CE 673 Industrial Water Supply and Waste Disposal. *Coreq.: CE 571. 3(3-0) F.* Water requirements of industry and the disposal of industries wastes. Graduate Staff

CE 674 Stream Sanitation. *Coreq.: CE 571. 3(3-0) S.* Biological, chemical and hydrological factors that affect stream sanitation and stream use. Graduate Staff

CE 681 Behavior and Analysis of Ocean Structures. *Preq.: CE 527. 3(3-0) S. Alt. yrs.* Introduction to linear and random water waves, analysis of wave forces on small bodies, analysis of wave forces on large bodies, response of offshore structures to waves and earthquake loadings, mooring dynamics. Tung

CE 685 Design of Coastal Facilities. *Preqs.: CE 582 and CE 583. 3(3-0) F.* Types and functions of coastal structures, computation of wave forces on coastal structures, wave uprush, shore protection against waves and storms, planning and design of navigation channels, port development, harbor design, dredging technology, planning and design of offshore platforms, technology of disposal of wastes and heated discharge, consideration of environmental effects of waste disposal. Fisher

CE 687 Numerical Modeling for Nearshore Flow Systems. *Preq.: CE 580 or CE 582 or MEA (CE) 541 or equivalent. 3(3-0) S.* Basic concepts of finite difference methods, methods of characteristics, estuarine and inlet flow computations, implicit methods, surge on the open coast. Introduction to circulation in sounds and bays, modeling of ocean circulation, modeling of sediment movement, mixing processes, water quality modeling. Graduate Staff

CE 689 Advanced Topics in Civil Engineering. *3(3-0) F,S.* New or special course on advanced developments in some phase of civil engineering. Specific topics and prerequisites are identified for each section and will vary from term to term. Graduate Staff

CE 698 Advanced Reading in Civil Engineering. *Preq.: Grad. standing. 1-3 F,S.* Directed reading of advanced topics in some phase of civil engineering. Graduate Staff

CE 699 Civil Engineering Research. *Credits Arranged. F,S.* Independent investigation of an advanced civil engineering problem; a report of such an investigation is required as a graduate thesis. Graduate Staff

Computer Science

GRADUATE FACULTY

Professor R. E. Funderlic, Head

Professor W. J. Stewart, Graduate Administrator

Professors: W. Chou, D. C. Martin, D. F. McAllister, H. G. Perros, R. J. Plemmons, K.-C. Tai, A. L. Tharp; *Professor Emeritus:* P. E. Lewis; *Associate Professors:* J. A. Bowen, E. W. Davis Jr., R. J. Fornaro, T. L. Honeycutt, H. D. Levin, W. E. Robbins, R. D. Rodman, C. D. Savage; *Assistant Professors:* D. R. Bahler, N. M. Bengston, R. A. Dwyer, E. F. Gehringer, J. Mauney, D. S. Reeves, M. F. M. Stallman, M. A. Vouk; *Assistant Professor Emeritus:* J. W. Hanson

ASSOCIATE MEMBERS OF THE DEPARTMENT

Professor: C. D. Meyer Jr.; Associate Professor: W. J. Rasdorf

The Department of Computer Science offers graduate programs leading to a Master of Science with thesis, Master of Science without thesis and Doctor of Philosophy. Also, cooperative Master's and Ph.D. programs are available with the Departments of Mathematics, Operations Research and Statistics.

Although the Department of Computer Science and the Department of Electrical and Computer Engineering administer separate graduate programs, they do so under a single, jointly held graduate computer engineering degree authorization. As a result, the departments cooperate closely in graduate education and research by sharing responsibility for a number of graduate courses, jointly operating the Computer Systems Laboratory, collaborating in research and administering a number of joint faculty appointments. The close cooperation of the departments offers graduate students in both disciplines an unusually wide range of educational and research opportunities.

Applicants for admission must have an undergraduate degree in computer science or its equivalent. This should include an extensive working knowledge of a high-level programming language such as Pascal or C, a knowledge of computer architecture and assembly language, operating systems and data structures. The applicant should also have had a three-course sequence in calculus and a course in probability theory.

Requirements for the M.S. degree include thirty credits (semester hours) beyond the B.S. Nine of the credit hours must be in a minor area such as mathematics, operations research, or electrical and computer engineering. For the Master's degree without thesis, the three core courses (CSC (ECE) 501, CSC 505 and CSC (ECE) 506) must be taken. In addition, nine of the credit hours must be chosen from a designated interest area. Currently these interest areas include architecture and VLSI, artificial intelligence, computer graphics, performance evaluation, computer communications, software systems and theory. For the Master's degree with thesis, the student must take CSC (ECE) 506 and either CSC (ECE) 501 or CSC 505. To pursue a Master's degree with thesis, the student must identify a suitable research topic and a member of the computer science graduate faculty who agrees to direct the research.

There is no prescribed minimum number of courses for the degree of Doctor of Philosophy. Normally, a student will take approximately sixty semester hours of course credits including the three core courses mentioned above. The actual courses to be taken are determined by the student's Ph.D. committee, made up of members of the graduate faculty. Independent reading and participation in seminars constitute an indispensable part of the doctoral program.

Each M.S. and Ph.D. student must pass a comprehensive final oral examination administered by the student's advisory committee. Additionally, each Ph.D. student must pass the departmental written qualifying examination and a preliminary examination which has a written and an oral component. Both components of the preliminary examination are administered by the student's advisory committee. Finally, the Ph.D. candidate must complete a thesis to the satisfaction of his/her Ph.D. advisory committee.

The Computer Science Department, the College of Engineering and the Graduate School can offer financial assistance of various kinds to qualified students and applicants. More information is available on request from the graduate administrator.

Artificial Intelligence Minor

Graduate students from outside of the Department of Computer Science wishing to minor in artificial intelligence should consult this catalog under *Artificial Intelligence*. The following computer science courses may be taken in partial fulfillment of the minor in artificial intelligence: CSC 502, CSC 511, ECE (CSC) 559, CSC (ECE, IE) 575, CSC 602, CSC 611, CSC (ECE, IE) 675.

SELECTED ADVANCED UNDERGRADUATE COURSES

CSC 412 Introduction to Computability, Languages and Automata. *Preq.: CSC 322. 3(3-0) F,S.*

CSC (MA) 416 Introduction to Combinatorics. *Preq.: MA 403 or CSC 322. 3(3-0) Alt. yrs.*

CSC 417 Theory of Programming Languages. *Preq.: CSC 322. 3(3-0) F,S.*

CSC 421 Introduction to Management Information Systems. *Preq.: CSC 311. 3(3-0) F.*

CSC 422 Management Information Systems. *Preq.: CSC 421. 3(3-0) S.*

CSC 423 Information Resources Management. *Preq.: CSC 421. 3(3-0) S.*

CSC (MA) 427 Introduction to Numerical Analysis I. *Preqs.: MA 301 or MA 312 and programming language proficiency. 3(3-0) F.*

CSC (MA) 428 Introduction to Numerical Analysis II. *Preqs.: MA 405 and programming language proficiency. 3(3-0) F.*

CSC 431 File Organization and Processing. *Preq.: CSC 311. 3(3-0) S.*

CSC 432 Database Management Systems. *Preq.: CSC 431. 3(3-0) F.*

CSC (ECE) 440 Digital Systems Interfacing. *Preq.: ECE 318 or CSC 312. 3(2-2) S.*

CSC (IE) 441 Introduction to Simulation. *Preqs.: Proficiency in a programming language, MA 202, ST 372. 3(3-0) F,S.*

CSC 442 Digital Simulation. *Preq.: CSC 441; Coreq.: ENG 321. 3(3-0) F,S.*

CSC 451 Operating Systems. *Preqs.: CSC 202, 256, 311. 3(3-0) F.*

CSC 452 Operating Systems Projects. *Preq.: CSC 451. 3(3-0) F,S.*

CSC 461 Computer Graphics. *Preqs.: MA 202 or MA 212; CSC 101 or CSC 111. 3(3-0) F.*

CSC 462 Computer Graphics Projects. *Preq.: CSC 461. 3(3-0) S.*

CSC 471 Programming Environments. *Preqs.: CSC 202, CSC 311. 3(3-0) F.*

CSC 472 Software Engineering Project. *Preq.: CSC 471; Coreq.: ENG 321. 3(3-0) S.*

CSC 481 Software Engineering with Ada. *Preq.: CSC 311. 3(3-0) F,S.*

CSC 495 Special Topics in Computer Science. *Preq.: CI. 1-6 F,S.*

CSC 499 Independent Research in Computer Science. *Preq.: CI. 1-6 F,S.*

FOR GRADUATES AND ADVANCED UNDERGRADUATES

CSC (ECE) 501 Operating Systems Principles. *Preqs.: CSC 201, CSC 311 and MA 421. 3(3-0) F,S.* This course covers fundamental issues for the design of operating systems. Topics include linkers and loaders, memory management, CPU and device scheduling, deadlocks, concurrency, protection and distributed systems.

CSC 502 Computational Linguistics. *Preq.: CI. 3(3-0) F.* Natural language processing by computer. Finite-state, context-free, context-sensitive and transformational grammars. Parsing mechanisms including augmented transition networks. Analysis of complex English sentences. Question-answering systems.

CSC 504 Application of Linguistic Techniques to Computer Problems. *Preq.: CSC 502. 3(3-0) S.* Semiotics and programming languages. Comparison of semantic theories. Representation, classification and interpretation of scenes and other multidimensional illustrations. Design of a formal language for describing two-dimensional geometric figures, such as flowcharts, chemical structures and logic diagrams. Characterization of programming languages according to the theory of transformational grammar.

CSC 505 Design and Analysis of Algorithms. *Preq.: CSC 311 or CSC 322. 3(3-0) F,S.* Study of techniques for the design of algorithms. Complexity and analysis of algorithms. Study of algorithms for certain classical problems that include sorting, searching, graphs, numerical algorithms and pattern matching.

CSC (ECE) 506 Digital Systems Architecture. *Preq.: ECE 340 or CSC 312. 3(3-0) F,S.* Digital systems architecture is the middle ground on which the interests of software, hardware and firmware come together. Among the topics considered: architectural descriptions, storage systems, I/O systems, stack machines and parallelism. The structure of digital systems implementation also considered as it relates to architecture.

CSC (ECE) 510 Software Engineering. *Preqs.: CSC 311 and CSC 322. 3(3-0) F.* The course introduces the principles, methods and tools for the design, coding and validation of software systems. Among the topics covered: software planning, cost estimation, software design techniques, programming methodology, program testing, proofs of program correctness, software reliability and software management.

CSC 511 Artificial Intelligence I. *Preq.: CSC 311 and either CSC 322 or PHI 201 or PHI 335 or background in symbolic logic. 3(3-0) F,S.* Introduction to and overview of artificial intelligence. Study of an AI programming language such as LISP or PROLOG. Elements of AI problem-solving techniques. State spaces and search techniques. Logic, theorem proving and associative databases. Introduction to knowledge representation, expert systems and selected topics including natural language processing, vision and robotics.

CSC (ECE) 512 Compiler Construction. *Preq.: CSC 311. 3(3-0) S.* This course intended to provide a detailed understanding of the techniques used in the design and implementation of compilers. Formal grammars and algorithms for lexical scanners, top-down recognizers, bottom-up recognizers for simple precedence grammars, operator precedence grammars, high order precedence grammars and bounded-context grammars. Runtime storage organization for a compiler including symbol tables, internal forms for source programs, semantic routines, error recovery and diagnostics, code generation and optimization and interpreters.

CSC (ECE) 513 Digital Signal Processing. *3(3-0) F.* (See electrical and computer engineering.)

CSC (ECE) 514 Random Processes. *3(3-0) F.* (See electrical and computer engineering.)

CSC (ECE) 518 Computer Graphics. *Preqs.: MA 405, knowledge of FORTRAN or PASCAL. 3(3-0) F.* Clipping, windowing, transformations, projections, hiddenline and surface removal, smooth shading, shadowing, translucence, reflection, refraction, curve and surface representation.

CSC (ECE) 520 Fundamentals of Logic Systems. *3(3-0) F.* (See electrical and computer engineering.)

CSC (ECE) 521 Digital Computer Technology and Design. *3(3-0) F,S.* (See electrical and computer engineering.)

CSC (MA) 529, 530 Numerical Analysis I, II. *3(3-0) F,S.* (See mathematics.)

CSC (ECE) 533 Digital Electronics. *3(3-0) S.* (See electrical and computer engineering.)

CSC 541 Advanced Data Structures. *Preq.: CSC 311. 3(3-0) F.* Complex and specialized data structures relevant to the design and development of effective and efficient software. Hardware characteristics of storage media. Primary file organizations. Hashing functions and collision resolution techniques. Low level and bit level structures including signatures, superimposed coding, disjoint coding and Bloom filters. Tree and related structures including AV1 trees, B*trees, tries and dynamic hashing techniques.

CSC (ECE) 542 Database Management. *Preq.: CSC 431 or CSC (ECE) 501. 3(3-0) F.* The course covers the fundamentals of the area of database management. Basic topics include: general architecture for database management systems; current data models such as network, relational, hierarchical; security and integrity; discussion of current implemented systems.

CSC (ECE) 558 Image Processing. *3(3-0) Every yr.* (See electrical and computer engineering.)

CSC (ECE) 559 Pattern Recognition. *3(3-0) S.* (See electrical and computer engineering.)

CSC (ECE, OR, IE) 562 Computer Simulation Techniques. *Preqs.: ST 516 and a scientific programming language. 3(3-0) F.* Basic discrete event simulation methodology: random number generators, simulation designs, validation, analysis of simulation output. Applications to various areas of scientific modeling. Simulation language such as SLAM and GPSS. Computer assignments and projects.

CSC (ECE) 571 Data Transmission/Communications. *Preqs.: CSC 312 or ECE 301. 3(3-0) S.* Deals with the principles and techniques of moving digital data through transmission facilities. To be covered: digital information representation; characteristics of channels; modulation and demodulation (MODEM) techniques; error detection and correction; line control procedure; circuit, message and packet switching; multiplexors and concentrators.

CSC (ECE) 572 Computer Communications. *Preq.: CSC 312 or ECE 340 or CSE 454; Coreq.: B average in technical subjects. 3(3-0) F.* The purpose of this course is to enable the student to understand the principles, the control and operations and the potential of computer communication systems; to present techniques for topological design and analytic modeling of such systems; and to provide the foundation for more detailed studies and research. The courses self-contained and focus on practical applications of state-of-art techniques.

CSC (ECE) 573 Introduction to Computer Performance Modelling. *Preqs.: CSE 454, MA 421; Coreq.: CSC 501. 3(3-0) F.* Workload characterization, collection and analysis of

performance data, instrumentation, tuning, analytic models including queueing network models and operational analysis, economic considerations.

CSC (ECE) 574 Real Time Computer Systems. *Preq.: CSC 405 or CSC (ECE) 501. 3(3-0) S.* Hardware and software characteristics of computer systems designed to meet specific response time requirements studied. Topics include allocation of system resources including processor memory, disk, support I/O devices; synchronous and asynchronous event scheduling; effect of interrupts; static and dynamic priorities; implementation of queues; measurement of performance, especially scheduling and response accuracy.

CSC (ECE, IE) 575 Voice Input/Output Communication Systems. *3(3-0) F.* (See industrial engineering.)

CSC (MA) 583 Numerical Solution of Ordinary Differential Equations. *Preq.: MA 512. 3(3-0) S.* Numerical methods for initial value problem including predictor-corrector, Runge-Kutta, hybrid and extrapolation methods; stiff systems; shooting methods for two-point boundary value problems; weak, absolute and relative stability results.

CSC (MA) 584 Numerical Solution of Partial Differential Equations—Finite Difference Methods. *Preq.: Knowledge to the level of CSC 427-428. 3(3-0) F,S.* Numerical methods for the solutions of parabolic, elliptic and hyperbolic partial differential equations including stability and convergence results.

CSC (MA, OR) 585 Graph Theory. *Preq.: MA 405. 3(3-0) F.* Basic concepts of graph theory. Trees and forests. Vector spaces associated with a graph. Representation of graphs by binary matrices and list structures. Traversability. Connectivity, Matching and assignment problems. Planar graphs. Colorability. Directed graphs. Applications of graph theory with emphasis on organizing problems.

CSC (MA) 587 Numerical Solution of Partial Differential Equations—Finite Element Method. *3(3-0) S.* (See mathematics.)

CSC 591 Special Topics in Computer Science. *Preqs.: B average in technical subjects and CI. 3(3-0) F,S.* Topics of current interest in computer science not covered in existing courses.

FOR GRADUATES ONLY

CSC 602 Computational Semantics. *Preqs.: CSC 502 and CSC 322 or equivalent. 3(3-0) S.* An examination of how to represent meaning in natural language to a computer. Logical systems for representing meaning. Other systems for representing meaning such as conceptual dependencies. Generating natural language output from data bases representing knowledge. Reading of advanced material in such areas as natural language dialogue processing.

CSC (OR) 605 Large Scale Linear Programming Systems. *3(3-0) S. Alt. yrs.* (See operations research.)

CSC (ECE) 606 Concurrent Software Systems. *Preq.: CSC (ECE) 501. 3(3-0) S.* This course covers concepts, techniques and tools for the development of concurrent (parallel or distributed) software systems. Topics include specification of concurrency, design of concurrent software systems, concurrent languages and validation of concurrent programs.

CSC 611 Artificial Intelligence II. *Preq.: CSC 511. 3(3-0) S.* This is a second course in artificial intelligence emphasizing advanced concepts of AI including logic programming, automatic programming, natural language understanding, visual perception by machine, learning and inference, intelligent computer-aided instruction, knowledge representation, robotics and other topics to be chosen by the instructor. Students asked to write programs in an AI programming language such as LISP and PROLOG.

CSC (ECE) 640 Advanced Logic Systems. 3(3-0) S. (See electrical and computer engineering.)

CSC (ECE) 641 Sequential Machines. 3(3-0) F. (See electrical and computer engineering.)

CSC (ECE) 651 Statistical Communication Theory. 3(3-0) S. (See electrical and computer engineering.)

CSC (ECE) 652 Information Theory. 3(3-0) F. (See electrical and computer engineering.)

CSC (ECE) 659 Computer Vision. 3(3-0) F. (See electrical and computer engineering.)

CSC (IE,OR) 662 Stochastic Simulation Design and Analysis. *Preqs.: CSC (ECE, IE, OR) 562 and ST 516.* 3(3-0) S. Advanced topics in stochastic system simulation covered, including random variate generation, output estimation for stationary and nonstationary models, performance optimization techniques, variance reduction approaches. Students apply these techniques to actual simulations. A paper written on a current research topic required.

CSC (ECE) 671 Advanced Computer Performance Modelling. *Preqs.: CSC (ECE) 573 or OR (IE) 561.* 3(3-0) S. *Alt. yrs.* In-depth study of computer performance modelling techniques such as exact and approximate analysis of queueing networks and direct and iterative numerical solutions of queueing systems.

CSC (MA) 672 Advanced Numerical Linear Algebra. 3(3-0) S. (See mathematics.)

CSC (MA) 673 Parallel Algorithms and Scientific Computation. 3(3-0) S. (See mathematics.)

CSC (MA) 674 Nonlinear Equations and Unconstrained Optimization. 3(3-0) S. *Alt. yrs.* (See mathematics.)

CSC (ECE, IE) 675 Advances in Voice Input/Output Communications Systems. 3(2-3) S. (See industrial engineering.)

CSC 691 Advanced Topics in Computer Science. *Preqs.: Grad. standing, CI.* 3(3-0) F,S. Advanced topics of current interest in computer science not covered by existing courses.

CSC 693 Individual Topics in Computer Science. *Preqs.: Grad. standing, CI.* 1-3 F,S. An opportunity for an individual graduate student to investigate special topics of interest under the direction of members of the graduate faculty.

CSC 695 Seminar in Computer Science. *Preqs.: Grad. standing, CI.* 1(1-0) F,S. Seminar discussion of problems of current research interests in computer science. Seminar speakers consist of advanced graduate students, faculty and invited speakers.

CSC 699 Computer Science Research. *Preqs.: Grad. standing, CI. Credits Arranged.* F,S. Individual research by graduate students minoring and majoring in computer science. Research may be done under the supervision of CSC faculty members meeting the interest and need of the student.

Counselor Education

For a listing of graduate faculty and departmental information, see counselor education under education.

Crop Science

GRADUATE FACULTY

Professor J. C. Wynne, Head

Professors: B. E. Caldwell, D. S. Chamblee, H. D. Coble, W. K. Collins, F. T. Corbin, E. J. Dunphy, D. A. Emery, W. T. Fike, M. M. Goodman, J. T. Green Jr., H. D. Gross, W. M. Lewis, R. C. Long, J. P. Mueller, R. P. Patterson, G. F. Peedin, T. J. Sheets, H. T. Stalker Jr., G. A. Sullivan, D. H. Timothy, J. B. Weber, W. W. Weeks, E. A. Wernsman, A. D. Worsham; *Professors (USDA):* J. C. Burns, J. W. Burton, G. R. Gwynn, S. C. Huber, D. E. Moreland, H. Seltmann, R. F. Wilson; *Adjunct Professors:* D. T. Patterson, L. Thompson Jr.; *Professors Emeriti:* C. T. Blake, C. A. Brim, J. F. Chaplin, W. A. Cope, D. U. Gerstel, W. B. Gilbert, W. C. Gregory, P. H. Harvey, G. L. Jones, J. A. Lee, R. P. Moore, L. L. Phillips, D. L. Thompson, J. A. Weybrew; *Associate Professors:* J. R. Anderson Jr., D. T. Bowman, J. M. DiPaola, R. E. Jarrett, R. D. Keys, H. M. Linkler, C. H. Peacock, A. C. York; *Associate Professors (USDA):* T. E. Carter Jr., J. E. Miller, T. W. Rufty, Jr.; *Assistant Professors:* A. H. Bruneau, D. A. Danehower, D. S. Guthrie, J. P. Murphy, S. M. Reed, R. C. Rufty, W. D. Smith, M. G. Waggoner, R. Wells, G. G. Wilkerson; *Assistant Professors (USDA):* J. M. Anderson, K. O. Burkey, J. M. Ferguson, D. Fisher, S. H. Kay, P. Kwanyuen, P. H. Sisco Jr., A. K. Weissinger

The Department of Crop Science offers instruction leading to the Master of Science and Doctor of Philosophy degrees in the fields of plant breeding, crop production and physiology, forage crops ecology, turfgrass science, weed control and plant chemistry. For students who wish general training, the Master of Agriculture is offered.

Excellent facilities for graduate training are available. Many special facilities such as preparation rooms for plant and soil samples, cold storage facilities for plant material, greenhouse space, growth control chambers and access to computer facilities and the plant environment laboratory (Phytotron) are provided if required. Research farms located throughout North Carolina include a variety of soil and climatic conditions needed for experiments in plant breeding, crop management, forage ecology and weed control. A turfgrass research facility is located near the campus.

Strong supporting departments increase opportunities for broad and thorough training. Among the departments in which graduate students in crop science work cooperatively or obtain instruction are Biochemistry, Botany, Chemistry, Computer Science, Entomology, Horticultural Science, Genetics, Mathematics, Microbiology, Plant Pathology, Soil Science and Statistics.

In North Carolina, a state which derives a major portion of its agricultural income from farm crops, opportunities for crop science graduates are great. Recipients of advanced degrees in crop science at North Carolina State University are found in positions of leadership in research and education throughout the nation and the world.

SELECTED ADVANCED UNDERGRADUATE COURSES

CS 411 Environmental Aspects of Crop Production. *Preq.: BO 421. 2(2-0) F.*

CS 413 Plant Breeding. *Preq.: GN 411. 2(2-0) S.*

CS 414 Weed Science. *Preq.: CH 220. 4(3-2) F.*

CS (SSC) 462 Soil-Crop Management Systems. *Preqs.: CS 211, CS 414, SSC 341, SSC 342, SSC 352, Sr. standing. 3(2-3) S.*

CS 490 Senior Seminar in Crop Science. *Preq.: Sr. in crop science or related field. 1(1-0) S.*

FOR GRADUATES AND ADVANCED UNDERGRADUATES

CS 511 Tobacco Technology. *Preq.: BO 421 or equivalent. 3(3-0) S.* A study of special problems concerned with the tobacco crop. The latest research problems and findings dealing with this important cash crop discussed. Peedin

CS 513 Physiological Aspects of Crop Production. *Preq.: BO 421. 3(3-0) S. Alt. yrs.* Discussion emphasizes pertinent physiological processes associated with crops and crop management such as plant growth, maturation, respiration and photoperiodism. Relationship of the environment to maximum crop yields discussed. Fike

CS (HS) 515 Weed Science Research Techniques. *Preq.: CS 414 or equivalent. 1(0-2) F.* Bioassay techniques for detection of herbicide residues in soils, chemical analytical (GLC, HPLC) techniques for identifying herbicide residues in soils and plants, procedures for studying adsorption and leaching in soils, procedures for measuring herbicide interference of photosynthesis and use of ^{14}C -labeled herbicides for following uptake, transport and metabolism of herbicides in plants. Graduate Staff

CS (HS) 516 Weed Biology. *Preq.: CS 414. 1(1-0) F.* Weed seed development and dispersal, seed dormancy, oil seed bank, seedling development, growth analysis, reproduction, community structure, population dynamics, species interactions, environmental effects on interactions and influence of man. Taught first 5 weeks of semester. Coble

CS (HS) 517 Weed Management Systems. *Preq.: CS 414 or equivalent. 1(1-0) F.* Weed management systems including integration of cultural, biological, mechanical, and chemical methods for vegetables, fruits, ornamentals, turf, small grains, corn, tobacco, cotton, peanuts, aquatic and non-cropland settings. Taught second 5 weeks of semester. Graduate Staff

CS (HS) 518 Biological Control of Weeds. *Preq.: CS 414 or equivalent. 1(1-0) F.* Concepts and methods in the use of biological agents for control of weeds. Primary emphasis on weed bio-control with insects and plant pathogens. Taught third 5 weeks of semester. Van Dyke

CS (GN, HS) 541 Plant Breeding Methods. *Preqs.: GN 506, ST 511. 3(3-0) F.* An advanced study of methods of plant breeding as related to principles and concepts of inheritance. Murphy, Wehner

CS (GN) 545 Origin and Evolution of Cultivated Plants. *Preq.: GN 505 or GN (ZO) 540. 3(3-0) S. Alt. yrs.* Review of progression to modern evolutionary thought; concepts of speciation and classification; origin of variation in plants; theories relating to origins of cultivation and spread of agriculture variation patterns and special attributes of cultigens; interactions of crops and environments; evolution under domestication; modern aspects of evolution as related to breeding. Stalker

CS (BO, GN, HS) 547 Cell and Tissue Techniques in Plant Breeding. *Preqs.: GN 505B and GN 506B or equivalent. 3(1-4) F. Alt. yrs.* Applications of tissue culture and cytogenetic techniques for plant improvement. Callus and suspension cultures, plant regeneration, *in vitro* selection, haploidy, polyploidy, aneuploidy, wide hybridization and embryo rescue. Practical lab experiences in tissue culture and cytogetic techniques. Stalker

CS 591 Special Problems. *Preq.: CI. Credits Arranged. F,S,Sum.* Special problems in various phases of crop science. Problems may be selected or will be assigned. Emphasis placed on review of recent and current research. Graduate Staff

FOR GRADUATES ONLY*

CS 611 Metabolism and Crop Productivity. *Preqs.: BCH 451; BO 551 or 552. 3(3-0) S. Alt. yrs.* A comprehensive examination of basic metabolic processes related to germination, cell wall formation, carbon and nitrogen utilization, and macromolecular biosynthesis and partitioning, and how these processes interact with plant genotype and environment to affect growth, development and dry matter accumulation in crop plants. Long

CS (HS, SSC) 614 Herbicide Behavior in Plants and Soils. *Preqs.: BO 551 and CH 223 or CI. 3(3-0) F. Alt. yrs.* The chemical and physiological processes involved in the behavior of herbicides in plants and soils examined. Topics to be discussed include absorption, translocation, metabolism and mechanisms of action of herbicides on plants; reactions, movement and degradation of herbicides in the soil; and interactions among herbicides and other pesticides. Weber

CS (GN, HS) 615 Quantitative Genetics in Plant Breeding. *Preqs.: CS (GN, HS) 541, ST 512, course in quantitative genetics recommended. 1(1-0) S. Alt. yrs.* Theory and principles of plant quantitative genetics. Experimental approaches of relationships between type and source of genetic variability, concepts of inbreeding, estimations of genetic variance and selection theory. Burton

CS (GN, HS) 616 Breeding Methods. *Preqs.: CS (GN, HS) 541, ST 512. 2(2-0) S. Alt. yrs.* Theory and principles of plant breeding methodology including population improvement, selection procedures, genotypic evaluation, cultivar development and breeding strategies. Wynne

CS (GN, HS) 617 Nonconventional Plant Breeding. *Preq.: CS (GN, HS) 541. 1(1-0) F. Alt. yrs.* Theory and principles of molecular and nonconventional plant breeding. Experimental approaches to induce genetic change, cytoplasmic recombination, haploid utilization and potentials of molecular techniques for solving breeding problems. Sisco

CS (GN, HS, PP) 618 Breeding for Pest Resistance. *Preqs.: CS (GN, HS) 541, PP 315, ST 512. 2(2-0) F. Alt. yrs.* Theory and principles of breeding for pest resistance. Experimental approaches for examining genetics of host-parasite interactions, expression and stability of pest resistance and breeding strategies for developing pest-resistant cultivars. Rufty

CS 690 Seminar. *Preq.: Grad. standing. 1(1-0) F,S.* A maximum of two credits allowed toward the master's degree; however, additional credits toward the doctorate allowed. Scientific articles, progress reports in research and special problems of interest to agronomists reviewed and discussed. Graduate Staff

CS 699 Research. *Preq.: Grad. standing. Credits Arranged.* A maximum of six credits allowed toward the master's degree, but no restrictions toward the doctorate. Graduate Staff

*Students are expected to consult with the instructor before registration.

Curriculum and Instruction

For a listing of graduate faculty and departmental information, see education.

Design

For a listing of graduate faculty and departmental information, see architecture, landscape architecture, product design.

SELECTED ADVANCED UNDERGRADUATE COURSES

- DN 400 Design Studio.** *Req.: DF 102 or written approval of dept. head. 6(0-9) F,S.*
- DN 411 Advanced Visual Laboratory.** *Preqs.: DF 102 or both DF 111 and DF 112. 3(0-6) F,S.*
- DN 412 Advanced Photography.** *Req.: DN 312. 3(1-4) S.*
- DN 413 Synthetic Drawing.** *Req.: DF 102. 3(2-3) F.*
- DN 414 Color and Light Laboratory.** *Req.: DF 102. 3(3-0) F,S.*
- DN 415 Microcomputer Graphics for Designers.** *3(3-0) S.*
- DN 419 Multi-Media in Design.** *Req.: DN 212. 3(1-4) S.*
- DN 421 Environmental Cognition for Designers.** *3(3-0) F.*
- DN 423 Concepts of Space.** *3(3-0) F.*
- DN 445 Aesthetics and Design.** *Req.: DN 141 or DN 142. 3(3-0) F.*
- DN 454 Geometry for Designers.** *Req.: Jr. standing. 3(3-0) S.*
- DN 491 Special Seminar in Design.** *1-3 F,S.*
- DN 492 Special Topics in Design.** *1-3 F,S.*
- DN 494 Internship in Design.** *Preqs.: Jr. standing, 3.0 GPA or better, approval of dept. head. 3-6 (Max. 6) F,S.*
- DN 495 Independent Study in Design.** *Preqs.: Jr. standing, 3.0 GPA or better, approval of dept. head. 1-3 (Max. 6) F,S.*

FOR GRADUATES AND ADVANCED UNDERGRADUATES

- DN 541 Seminar on Ideas in Design.** *Req.: Grad. standing. 2-3 F,S.* An examination of aesthetics and the relationships of philosophic thought to design.

FOR GRADUATES ONLY

- DN 611 Advanced Visual Laboratory.** *Req.: Grad. standing; may be taken for a maximum of 12 credit hours. 2-4 F,S.* Advanced experimental studies in visual phenomena related to design.

Ecology

GRADUATE FACULTY

Professor A. G. Wollum II, Chair

Professors: D. A. Adams, S. P. S. Arya, R. C. Axtell, K. R. Barker, D. M. Benson, U. Blum, J. R. Bradley Jr., S. W. Buol, D. S. Chamblee, A. W. Cooper, B. J. Copeland, P. D. Doerr, G. H. Elkan, D. J. Frederick, L. F. Grand, H. D. Gross, F. P. Hain, D. Kamykowski, G. G. Kennedy, J. M. Miller, K. H. Pollock, L. A. Real, E. D. Seneca, D. L. Solomon, R. E. Stinner, H. R. van der Vaart, T. R. Wentworth, T. G. Wolcott, A. D. Worsham; *Professor (USDA):* J. C. Burns; *Professor (USDI):* M. T. Huish; *Professors Emeriti:* F. E. Guthrie, D. W. Hayne, T. O. Perry; *Associate Professors:* H. L. Allen Jr., C. Brownie, L. B. Crowder, J. M. DiPaolo, F. L. Gould, B. C. Haning, R. A. Lancia, S. C. Mozley, R. A. Powell, J. R. Walters; *Associate Professor (USDA):* K. P. Burnham; *Assistant Professors:* D. M. Checkley Jr., L. A. Levin

Ecology is the science concerned with the interactions of organisms with each other and with their environment. It is an integrative science through which one gains an understanding of biological and physical interrelationships and predicts the consequences of altering one or several components of an ecosystem.

Students in a number of basic and applied curricula may elect to major in ecology at the master's level leading to an M.S. degree or minor in ecology at the master's and Ph.D. levels. The minor provides an opportunity for a coherent picture of the field of ecology but does not usurp the normal prerogatives of graduate advisory committees in structuring graduate programs.

The ecology minor is an interdepartmental program drawing faculty from the botany, crop science, entomology, forestry, marine, earth and atmospheric sciences, microbiology, plant pathology, soil science, statistics and zoology departments. The program is administered by the Ecology Advisory Committee. Additional information about the program may be obtained by writing to one of the faculty members listed above or to Chair, Ecology Faculty, P. O. Box 7619, North Carolina State University, Raleigh, North Carolina 27695-7619.

The following courses are recognized as ecological and have been grouped into certain related areas. (For course descriptions, see respective departmental listings.)

General Ecology: BO (ZO) 560 Principles of Ecology; BO 565 Plant Community Ecology; BO (ZO) 660 Advanced Topics in Ecology I.

Population Ecology: ZO 517 Population Ecology; ENT 531 Insect Ecology.

Limnology and Marine Science: ZO 419 Introduction to Limnology; ZO (ENT) 509 Ecology of Stream Invertebrates; ZO (MEA) 520 Principles of Biological Oceanography; ZO 619 Advanced Limnology.

Behavior: ZO 410 Introduction to Animal Behavior; ZO 501 Ornithology; ZO 691 Topics in Animal Behavior.

Microbial Ecology: MB 501A,B,C Advanced Microbiology I (A-Metabolism; B-Physiology; C-Immunology); SSC (MB) 532 Soil Microbiology; PP 611 Advanced Plant Nematology; PP (BO) 625 Advanced Mycology.

Terrestrial Ecology: BO 544 Plant Geography; ZO 544 Mammalogy; SSC 551 Soil Morphology, Genesis and Classification; MEA 555 Meteorology of the Biosphere.

Physiological Ecology: ZO (PHY) 513 Comparative Physiology; ZO (FW) 515 Fish Physiology; BO 561 Physiological Ecology.

Mathematical Biology and Ecology: ZO (FW) 553 Principles of Wildlife Science; BMA (MA, ST) 571, 572 Biomathematics I, II.

Applied Ecology: CS 411 Environmental Aspects of Crop Production; ZO (FW) 420 Fishery Science; ZO 441 Ichthyology; FOR 452 Silvics; FOR 472 Renewable Resource Policy and Management; SSC 472 Forest Soils; TOX 515 Environmental Toxicology; ENT 550 Fundamentals of Insect Control; ZO (FW) 554 Wildlife Field Studies; ENT 562 Insect Pest Management in Agricultural Crops; ENT (ZO) 582 Medical and Veterinary Entomology; FOR 613 Special Topics in Silviculture; FOR 614 Advanced Topics in Administration of Forest Resources; BO 662 Applied Coastal Ecology.

The requirements for a major in Ecology are:

Master of Science Degree: Six courses including BO (ZO) 560 (or its equivalent), either BO 565, BO (ZO) 660, ST 511, ECO 690 and one course from each of two designated areas (population ecology, limnology and marine science, etc.). The latter two courses should not be in the same department as the major professor.

The requirements for a minor in Ecology are:

Master of Science Degree: Three ecological courses, including BO (ZO) 560 (or its equivalent) and either BO 565 or BO (ZO) 660. The third course should not be in the same department as the major.

Ph.D. Degree: Four ecological courses, including BO (ZO) 560 (or its equivalent) and at least one other course from the general ecology area. One course outside the general ecology area is required. If more than one course is taken from outside the general ecology area, these courses must come from different designated areas (*i.e.*, population ecology, limnology and marine science, etc.). Courses outside the general ecology area should not be from the same department as the major.

Incoming students may apply equivalent courses toward these requirements at the discretion of their graduate committees. Students minoring in ecology, particularly at the Ph.D. level, are encouraged to take courses in mathematics and statistics, at least ST 511 and ST 512.

FOR GRADUATES ONLY

ECO 690 Ecology Seminar. *Preq.: Grad. standing. 1(1-0) F.* Scientific articles, progress reports and special problems of interest to ecologists are reviewed and discussed. Minimum of one seminar presentation required for credit.

ECO 693 Special Problems in Ecology. *Preq.: Grad. standing. 1-6 F,S,Sum.* Investigation of special problems in ecology of particular interest to advanced students under the direction of a faculty member. Directed research in some specialized phase of ecology other than a thesis problem, but designed to provide experience and training in research.

Economics and Business

GRADUATE FACULTY

Professor D. M. Hoover, Head

Professor C. R. Knoeber, Graduate Administrator

Associate Professor S. E. Margolis, Management Program Director

Graduate Advisor and Program Assistant B. L. Puryear

Professors: S. G. Allen, G. A. Carlson, R. L. Clark, A. J. Coutu, R. D. Dahle, L. E. Danielson, J. E. Easley Jr., E. W. Erickson, R. M. Fearn, D. Fisher, A. R. Gallant, T. J. Grennes, J. D. Hess, D. L. Holley Jr., D. M. Holthausen Jr., D. N. Hyman, L. A. Ihnen, P. R. Johnson, T. Johnson, C. P. Jones, C. J. Messere, C. L. Moore Sr., E. C. Pasour Jr., D. K. Pearce, R. J. Peeler, R. K. Perrin, R. A. Schrimper, J. J. Seater, V. K. Smith, D. A. Sumner, R. E. Sylla, C. B. Turner, M. L. Walden, P. F. Williams, M. K. Wohlgenant; *Extension Professors:* H. L. Liner, R. C. Wells; *Professors Emeriti:* R. C. Brooks, R. A. King, T. E. Nichols Jr., B. M. Olsen, C. R. Pugh, J. A. Seagraves, R. L. Simmons, J. G. Sutherland, W. D. Toussaint, J. C. Williamson Jr.; *Associate Professors:* D. S. Ball, J. W. Bartley, D. L. Baumer, G. A. Benson, J. C. Dutton Jr., E. A. Estes, D. J. Flath, K. B. Frazier, E. Gerstner, J. S. Lapp, S. J. Liebowitz, E. A. McDermed, M. B. McElroy, R. B. Palmquist, J. C. Poindexter Jr., J. W. Rockness, R. J. Rossana, C. D. Safley, W. N. Thurman, W. J. Wessels, J. W. Wilson, G. J. Zuckerman; *Associate Professors Emeriti:* H. C. Gilliam Jr., C. W. Harrell Jr.; *Assistant Professors:* B. Babcock, R. N. Collender, P. L. Fackler, T. A. Feitshans, L. B. Ferreri, T. R. Fortenbery, A. R. Hall, A. E. Headen, D. L. Hoag, A. J. McKee Jr., K. Mitchell, C. M. Newmark, R. R. Rucker, K. D. Zering

Economics and Business offers programs of study leading to the Master of Economics, the Master of Arts in economics, the Master of Science in agricultural economics, the Master of Science in management (in conjunction with other departments) and the Ph.D. degree in economics. Emphasis is placed on economic theory and quantitative economic analysis and their application to economic problems. Special seminars and workshops are available to students as a means of pursuing topics of special interest.

The Master of Economics and the Master of Arts in economics require a minimum of 30 hours of course work. Flexible course requirements permit a student, in consultation with a graduate advisory committee, to develop a program to meet individual academic and career objectives. Price Theory (EB 501), Income and Employment Theory (EB 502) and a nine-hour minor in a discipline outside economics and business are required. The most popular minor discipline is statistics, but many departments offer minor programs, including Industrial Engineering, Operations Research, Mathematics, and Political Science and Public Administration. The remaining course work (fifteen hours) is selected from the varied economics and business offerings below. The Master of Arts in eco-

nomics differs from the Master of Economics only in that the former substitutes six hours of thesis research for six hours in the major.

The Master of Science in agricultural economics also requires a minimum of 30 hours of course work. EB 501, EB 502, one course from the agricultural economics offerings and a nine-hour minor from outside economics and business are required. The statistics minor is often chosen since six hours of statistics are required for this degree. A thesis is required and six hours of research study toward the thesis can be included in the program. The remaining course work is selected from such areas as agricultural production economics, agricultural policy, agricultural markets, managerial finance, natural resources and so forth, according to the student's interests.

Prerequisites for any of these programs include one semester each of intermediate microeconomics and macroeconomics and a minimum of one semester of calculus. A full year of calculus is advised. Domestic students may complete these prerequisite courses by registering through the Division for Lifelong Education in a special part-time preparatory program, Post-baccalaureate Studies (PBS). GRE scores are not required of applicants but are recommended.

The Master of Science in management (MSM) degree emphasizes the application of quantitative techniques and economic analysis to management decision making. This unique program is the result of the combined efforts of nine academic areas and provides students an opportunity to concentrate in a field of study offered by any of these departments. This concentration is known as the student's technical option and can be completed in: Biotechnology, Civil Engineering, Computer Studies, Economics and Business, Industrial Engineering, Management Information Systems, Operations Research, Statistics, Telecommunications Systems Engineering, and Textile and Apparel Management. See the complete description of this program, including the core management and economics course work in this bulletin, listed under Management.

The Ph.D. program has no specific hour requirements; however, at least six semesters of work beyond the bachelor's degree are required, of which at least two consecutive semesters must be in residence. Candidates take course work and written examinations in economic theory and complete a minor of their choice. In addition, each student chooses a concentrated field of study within economics (*e.g.*, agricultural economics, econometrics, applied macroeconomics, international trade, resource and environmental economics, labor economics and human resources or industrial organization). A minimum of two semesters of differential and integral calculus and a master's degree are prerequisites for the Ph.D. program. Students possessing only a bachelor's degree may enter one of the master's programs and complete courses which may be applied toward the Ph.D. There is no foreign language requirement for the Ph.D. GRE scores are not required of applicants but are recommended.

Microcomputer, mainframe computer access and library facilities are available to students for course work and research uses. The Microcomputer Instructional Laboratory consists of forty-five IBM personal computers linked to printers and memory devices in a local area network. In addition, the Programming Applications Laboratory provides technically trained programming personnel to assist in the preparation of work for mainframe computing. A well-equipped economics and business library, the University's D. H. Hill Library and library facilities of two nearby major universities are readily available for graduate

student use. Graduate students on financial support are provided study carrels or office space.

The services of the University's Career Planning and Placement Center are available to all students. In addition, economics and business employs a placement counselor to serve its current students and recent graduates.

For additional information, contact Bobby L. Puryear, Graduate Advisor, Economics and Business, Box 8109, North Carolina State University, Raleigh, NC 27695-8109, phone (919) 737-7157.

SELECTED ADVANCED UNDERGRADUATE COURSES

ACC 480 Accelerated Survey of Financial and Management Accounting. *Credit may not be received for both ACC 480 and ACC 220, 280 or 469. Intended for graduate students and advanced undergraduates not in Economics and Business. 3(3-0) F.*

EB 401 Economic Analysis for Nonmajors. *Preq.: EB 201 or 212. 3(3-0) F,S.*

EB 404 Money, Financial Markets, and the Economy. *Preq.: EB 302. 3(3-0) F,S.*

EB 410 Public Finance. *Preq.: EB 301. 3(3-0) F.*

EB 413 Competition, Monopoly and Public Policy. *Preq.: EB 301. 3(3-0) S.*

EB 415 Farm Appraisal and Finance. *Preq.: EB 303 or 310. 3(2-2) F.*

EB 420 Financial Management of Corporations. *Preqs.: EB 201 or 212 and ACC 260 or 265. 3(3-0) F,S.*

EB 422 Investments and Portfolio Management. *Preqs.: EB (ST) 350 or ST 311 and EB 320. 3(3-0) F,S.*

EB 425 Quantitative Methods for Management. *Preqs.: EB 201 or 212 and EB (ST) 350. 3(3-0) F,S.*

EB 430 Agricultural Price Analysis. *Preq.: EB 301. 3(3-0) F.*

EB 431 Labor Economics. *Preq.: EB 301. 3(3-0) F,S.*

EB 435 Urban Economics. *Preq.: EB 301. 3(3-0) F,S.*

EB 436 Environmental Economics. *Preq.: EB 301. 3(3-0) S.*

EB 442 Evolution of Economic Ideas. *Preq.: EB 202 or 212. 3(3-0) F.*

EB 448 International Economics. *Preq.: EB 301. 3(3-0) F,S.*

EB 451 Introduction to Econometrics. *Preqs.: EB 301, 302, 350. 3(3-0) F.*

EB (HI) 470 The Japanese Economy. *Preqs.: EB 301; 3 hours HI. 3(3-0) S.*

EB 475 Comparative Economic Systems. *Preq.: EB 201 or 212. 3(3-0) F,S.*

EB (TX) 482 Textile Marketing Management. *Preqs.: EB 301, EB 313, TX 380. 3(2-2) F,S.*

FOR GRADUATES AND ADVANCED UNDERGRADUATES

ACC 520 Advanced Management Accounting. *Preqs.: ACC 480, EB (ST) 350 and EB 501. 3(3-0) S.* Uses of accounting data for management decisions within the firm; applications of formal analytical models including decision theory, statistical analysis of cost behavior and optimization models; management and control of decentralized operations; and design and evaluation of accounting systems. Graduate Staff

EB 501 Price Theory. *Preqs.: MA 113 and EB 301. 3(3-0) F,S,Sum.* An intensive analysis of the determination of prices and of market behavior, including demand, cost and production, pricing under competitive conditions and pricing under monopoly and other imperfectly competitive conditions. Graduate Staff

EB 502 Income and Employment Theory. *Preqs.: EB 301, EB 302, EB (ST) 350, MA 113. 3(3-0) F,S,Sum.* Determinants of national income, employment, wages, the interest rate and inflation. Emphasis on the real (as opposed to monetary) determinants of these variables and on the microfoundations of modern macroeconomics. Discussion of monetary and fiscal policy and stochastic elements in income determination. Graduate Staff

EB (RRA) 503 Economics of Recreation. *3(3-0) F.* (See recreation resources administration.)

EB 504 Monetary and Financial Macroeconomics. *Preq.: EB 502. 3(3-0) S. Alt. yrs.* Financial and monetary determinants of national income and employment and the levels of wages, the interest rate and inflation. Emphasis on the money supply and the banking system. Special topics include banking regulation, budgetary deficits and the dynamics of money stock determination. D. Fisher, Pearce

EB 512 Law and Economics. *Preq.: EB 301 or EB 401. 3(3-0) F. Alt. yrs.* An economic analysis of the sources and effects of law, including common law, statutory law and regulation. Topics discussed include property rights and contracts, liability rules, crime and punishment, statutory enactment, bureaucratic behavior and institutional reform. Baumer, Knoeber

EB 513 Research Methods in Marketing. *Preqs.: EB 313, EB 350, EB 501. 3(3-0) S.* A systematic approach to the structure, implementation and analysis of marketing research for decision making. Models of consumer demand and firm behavior analyzed in a marketing context. Gerstner, Liebowitz

EB 515 Environmental and Resource Policy. *Preq.: EB 301 or EB 401. 3(3-0) F. Alt. yrs.* Application of price theory and benefit-cost analysis to public decisions related to resources and the environment. Emphasis on evaluation of water supply and recreation investments, water quality management alternatives, public-sector pricing, common property resources and optimum management of forest and energy resources. Palmquist, Rucker

EB 520 Managerial Finance: Theory and Applications. *Preqs.: EB 420 and EB 301 or 401. 3(3-0) F,S.* The foundations of finance theory and the empirical evidence available regarding the theory. Applications of basic finance theory, including capital budgeting, markets, valuation, cost of capital, financing alternatives, dividend policy and management of liquid assets. The micro-finance decisions made by a firm, primarily the investment, financing and dividend decisions. Jones, Mitchell

EB 521 Markets and Trade. *Preq.: EB 301 or 401. 3(3-0) F.* This course emphasizes the space, form and time dimensions of market price and the location and produce combination decisions of firms. Consideration given to the way in which non-price factors and public policy choices influence firm behavior and the efficiency of marketing systems. Application of these models to agricultural, industrial and public service questions emphasized, including the relationships between resource availability and the spatial arrangement of economic activity. Dahle, King

EB 522 Portfolio and Capital Market Theory. *Preqs.: EB 501 and EB 350 or ST 311. 3(3-0) F.* Portfolio theory and its applications, plus capital market theory and the equilibrium pricing of financial assets. The role of securities, utility theory and analysis of secondary markets and their efficiency and the definition and measurement of returns and risks. Valuing securities, including options contracts. Jones, Mitchell

EB 523 Planning Farm and Area Adjustments. *Preqs.: EB 301, 303 or 401. 3(2-2) S. Alt. yrs.* The application of economic principles to production problems on typical farms in the state; methods and techniques of economic analysis of the farm business; application of research findings to production decisions; development of area agricultural programs. Graduate Staff

EB 524 Financial Markets. *Preq.: EB 501. 3(3-0) S.* The economic characteristics of financial markets and instruments: determination of interest rates; structure of domestic financial markets; flow of funds; nature of financial institutions; nature of financial instruments; and financial market behavior. Jones, Mitchell

EB 525 Managerial Economics. *Preq.: EB 301 or 401. 3(3-0) S.* Applications of economic theory to the study of selected business practices in realms of finance, marketing, and management decision making. Specific topics have included: capital budgeting, financial structure, government regulation of industry, pricing strategies, tie-in sales, contractual arrangements between manufacturers and retailers, comparisons of managerial behavior in nonprofit or government enterprise to that in for-profit firms. Holthausen, Margolis

EB 526 Human Resource Management. *Preq.: EB 301. 3(3-0) F. Alt. yrs.* Application of decision-making techniques and economic models to problems of human resource management. Problems, causes and solutions analyzed in relationship to maximizing profits. Nature and impact of government regulations on human resource management. Allen, Clark, Wessels

EB 532 Economics of Trade Unions. *Preq.: EB 301 or 401. 3(3-0) F.* An examination of the growth of the trade union movement in the United States. Primary consideration given to the impact of unions on the economy through their influence on wages, prices, employment and resource allocation. Other topics include the relationship between the government and unions, the changing compensation mix and the recent growth in public employee unionism. Allen, Clark

EB 533 Economics of World Food and Agricultural Policy. *Preq.: EB 301 or 401. 3(3-0) F.* Economic analysis of the causes and effects of agricultural policies commonly applied in developed, developing and planned economies. Emphasis on economic models of policy analysis. Examination of the impact of commodity, farm input, international trade, consumer and general economic policies on agriculture and the whole economy. Effects of policy on income distribution and economic development. P. Johnson, Sumner

EB 540 Economic Development. *Preq.: EB 301 or 401. 3(3-0) Alt. yrs.* An examination of the problems encountered in promoting regional and national economic development. Consideration given to the structural changes required for raising standards of living. Some basic principles of economics applied to suggest ways of achieving development goals. Topics include planning strategies, policies and external assistance. Sumner

EB 551 Agricultural Production Economics. *Preqs.: MA 113 and EB 301 or EB 401. 3(3-0) S.* An economic analysis of agricultural production including: production functions, cost functions, programming and decision-making principles. Applications of these principles to farm and regional resources allocation, and to the distribution of income to and within agriculture. Carlson, Perrin

EB 560 Marketing Management and Strategy. *Preq.: EB 401 or EB 501. 3(3-0) F.* Analytical approach to marketing problems facing business firms and nonprofit organizations. Emphasis on management decision making and societal issues. Topics include marketing concepts, economic environment, marketing strategy and research, buyer behavior,

market segmentation and target marketing, product development and management, marketing and public policy, pricing strategies, channels of distribution, advertising and sales promotions.

Gerstner, Liebowitz

EB (ST) 561 Intermediate Econometrics. *Preqs.: EB 501 and ST 513. 3(3-0) S.* The formalization of economic hypotheses into testable relationships and the application of appropriate statistical techniques emphasized. Major attention be given to procedures applicable for single equation stochastic models expressing microeconomic and macroeconomic relationships. Statistical considerations relevant in working with time series and cross sectional data in economic investigations covered. Survey of simultaneous equation models and the available estimation techniques.

McDermed, Thurman

EB 565 Mathematical Methods for Economics. *Preqs.: EB 501, MA 231 or equivalent, introductory course in linear algebra. 3(3-0) S.* Linear algebra and matrices, optimization with equality and inequality constraints, comparative statics, differential and difference equations, intertemporal optimization. Economic applications to utility and profit maximization, national income determination, economic growth, business cycles.

Fackler, Hess

EB 570 Analysis of American Economic History. *Preq.: EB (HI) 371 or grad. standing or PBS status. 3(3-0) F. Alt. yrs.* Stresses the application of economic analysis to the formulation and testing of hypotheses concerning economic growth and development in the historical context. Problems selected for analysis drawn primarily from American economic history.

Sylla

EB (TX) 585 Market Research in Textiles. *3(3-0) S.* (See textile materials and management.)

EB 590 Special Economics Topics. *Preq.: CI. Maximum 6. F,S,Sum.* An examination of current problems on a lecture-discussion basis. Course content varies as changing conditions require new approaches to deal with emerging problems.

Graduate Staff

EB 598 Topical Problems in Economics. *Preq.: CI. 1-6. F,S,Sum.* An investigation of topics of particular interest to advanced students under faculty direction on a tutorial basis. Credits and content vary with student needs.

Graduate Staff

FOR GRADUATES ONLY

EB 600 Advanced Price Theory. *Preqs.: EB 501, MA 212. 3(3-0) F.* Theory of consumer behavior. Derivation of individual and market demand curves. Consumer surplus. Derivation of firm and market supply curves. Equilibrium and price determination in a market economy. Consideration of alternative market structures.

Hess, Palmquist

EB 601 Prices, Value and Welfare. *Preq.: EB 600. 3(3-0) S.* Production and duality theory. The demand for and supply of factors of production. Theories of capital and interest. Welfare economics topics, including externalities, compensation, public goods and the social welfare function. General equilibrium.

Rucker, Thurman

EB 602 Advanced Income and Employment Theory. *Preq.: EB 502. 3(3-0) F.* An analysis of the forces determining the level of income and employment; a review of some of the theories of economic fluctuations; and a critical examination of a selected macroeconomic system.

Rossana, Seater

EB 603 History of Economic Thought. *Preqs.: EB 501 and 502 or equivalent. 3(3-0) Sum. Alt. yrs.* A systematic analysis of the development and cumulation of economic thought, designed in part to provide a sharper focus and more adequate perspective for the understanding of contemporary economics.

D. Fisher

EB 604 Monetary Economics. *Preq.: EB 602. 3(3-0) S.* Consideration of the money market and portfolio management, the cost of capital, effects of monetary phenomena on

investment and accumulation of wealth with emphasis throughout on problems arising from uncertainty; general equilibrium theory of money, interest, prices and output.

D. Fisher, Lapp, Pearce

EB 606 Industrial Organization and Control. *Preq.: EB 501. 3(3-0) F.* Microeconomic theory is applied to the empirical analysis of public policies that affect the efficiency of resource allocation in the U. S. economy. Special attention is given to the interrelationships between industrial structure, conduct and performance.

Flath, Margolis

EB 610 Theory of Public Finance. *Preq.: EB 501. 3(3-0) F. Alt. yrs.* An application of microeconomic theory and welfare economics to the public sector. Topics include externalities and public policy, the theory of public goods, collective choice, program budgeting and cost-benefit analysis, the theory of taxation and its application to tax policy, public debt, and fiscal federalism.

Hyman

EB 615 Environmental and Resource Economics. *Preq.: EB 501. 3(3-0) S.* The theoretical tools and empirical techniques necessary for an understanding of resource and environmental economics, developed in both a static and dynamic framework. Discussions of the causes of environmental problems, possible policies and approaches to nonmarket valuation. Analysis of resource use over time using control theory for both renewable and exhaustible resources.

Palmquist, Rucker, Smith

EB 625 Long Range Planning in Business and Industry. *Preq.: EB 501. 3(3-0) S.* Theory and practice of long range planning in business and industry. Case discussions and intensive readings dealing with techniques for identifying opportunities and risks in the environment of the firm, determining corporate strengths and weaknesses, specifying long range strategy. Special attention is given to the roles of management and the internal processes of large organizations as the organizations respond to changes in external conditions.

Holthausen, Newmark

EB 630 Labor Economics. *Preqs.: EB 501 and one of the following: EB (ST) 561, ST 422, ST 512, ST 517. 3(3-0) F.* Application of microeconomic theory and econometric methods to labor market behavior in both static and dynamic contexts. Topics include labor demand analysis, labor force participation, hours of work, household production, human capital, distribution of earnings, information and search, and mobility.

Allen, Fearn

EB 631 Policy and Research Issues in Labor Economics. *Preqs.: EB 501 and one of the following: EB (ST) 561, ST 422, ST 512, ST 517. 3(3-0) S.* Survey of current literature on policy-related issues in labor economics, including trade union behavior, unemployment, macroeconomic aspects of labor market adjustment, discrimination, regulation of wages and benefits and public-sector labor markets. Examples from labor markets in the U. S. and developing countries. Recent research developments in labor economics, topics to vary according to the interests and needs of students.

Allen, Clark

EB 640 Advanced Economic Development. *Preqs.: EB 501, 502, 540. 3(3-0) F. Alt. yrs.* An analysis of the factors determining the growth of poorer countries and regions of countries. Consideration given to issues that have arisen in current theoretical and empirical bases for policy decisions. Included in the latter elements are the quantitative foundations for planned and programmed development. Applications of alternative planning methods evaluated.

King, Sumner

EB 641 Agricultural Production and Supply. *Preqs.: EB 501 and ST 513. 3(3-0) F.* An advanced study in the logic of, and empirical inquiry into, producer behavior and choice among combinations of factors and kinds and qualities of output; aggregative consequences of individuals' and firms' decisions in terms of product supply and factor demand; factor markets and income distribution; and general interdependency among economic variables.

Carlson, Perrin, Sumner

EB 642 Consumption, Demand and Market Interdependency. *Preqs.: EB 501 and ST 513. 3(3-0) S.* An analysis of the behavior of individual households and of consumers in the

aggregate with respect to consumption of agricultural products; the impact of these decisions on demand for agricultural resources, the competition among agricultural regions and for markets; and the interdependence between agriculture and other sectors of the economy.
Thurman, Wohlgenant

EB 648 Theory of International Trade. *Preqs.: EB 501, 502. 3(3-0) S.* A consideration of the specialized body of economic theory dealing with the international movement of goods, services, capital and payments. Also, a theoretically oriented consideration of policy.
Dutton, P. Johnson

EB 649 Monetary Aspects of International Trade. *Preq.: EB 502. 3(3-0) F.* Study of the macroeconomic problems of an open economy including the balance of payments adjustment mechanism, alternative exchange rate systems, external effects of monetary and fiscal policy, optimum currency areas and international monetary reform.
Grennes

EB 650 Economic Decision Theory. *Preq.: EB 501. 3(3-0) S. Alt. yrs.* Study of general theories of choice. Structure of decision problems, the role of information; formulation of objectives. Current research problems.
Hess, Holthausen

EB(ST) 651 Econometrics. *Preqs.: EB 600, ST 421, ST 502. 3(3-0) F.* The role and uses of statistical inference in economic research; the problem of spanning the gap from an economic model to its statistical counterpart; measurement problems and their solutions arising from the statistical model and the nature of the data; limitations and interpretation of results of economic measurement from statistical techniques.
Hall, Smith

EB (ST) 652 Topics in Econometrics. *Preq.: EB (ST) 651. 3(3-0) S.* Survey of current literature on estimation and inference in simultaneous stochastic equations systems. Techniques for combining cross section and time series data including covariance, error correlated and error component models. Lag models and inference in dynamic systems. Production functions, productivity measurement and hypotheses about economic growth. Complete and incomplete prior information in regression analysis. Nonlinear estimation in economic models.
Gallant, Schrimper

EB 682 Advanced Macroeconomics. *Preq.: EB 602. 3(3-0) F. Alt. yrs.* Advanced study of macroeconomics. Emphasis on business cycles and behavior of real variables. Topics include: real, incomplete information and disequilibrium theories of the business cycle; rational expectations; contract theory and indexation; investment; and the effects of government expenditure, taxes and debt.
Rossana, Seater

EB 684 Monetary Theory. *Preqs.: EB 600, 601, 602, 604. 3(3-0) F. Alt. yrs.* Advanced study of micro- and macro-economic theories of the role of money in the economy. Primary emphasis on money demand and monetary growth models. Specific areas explored include: traditional and recent developments in both asset and transactions theory and rational expectations and optimal policy. Discussion of the empirical record included for most topics.
D. Fisher, Pearce

EB 699 Research in Economics. *Preq.: Grad. standing. Credits Arranged.* Individual research in economics under staff supervision and direction.
Graduate Staff

Education

GRADUATE FACULTY

Professor J. J. Michael, Dean

The following master's degree programs are offered by the School of Education:

- Adult and Community College Education
- Agricultural Education
- Curriculum and Instruction
- Educational Administration and Supervision
- Guidance and Personnel Services
- Higher Education Administration
- Industrial Arts Education
- Mathematics Education
- Middle Grades Education
- Occupational Education
- Psychology
- Science Education
- Special Education
- Vocational Industrial Education

Students accepted into any of the above education programs may seek either the Master of Science degree or the Master of Education degree; students admitted to the Department of Psychology seek the Master of Science degree. The Master of Science degree is research-oriented and is preparation for further graduate study. The Master of Education is a professional degree which allows for wider latitude in the choice of course work than is allowed by the Master of Science program.

The College of Education and Psychology also offers certification programs at the intermediate (sixth-year) level in the following fields:

- Agricultural Education
- Community College Administration
- Curriculum and Instruction
- Educational Administration and Supervision
- Educational Gerontology
- School Counseling
- Mathematics Education
- Occupational Education
- School Psychology
- Science Education
- Special Education
- Vocational Industrial Education

The following doctoral programs are offered by the College of Education and Psychology:

Adult and Community College Education	Ed.D.
Curriculum and Instruction	Ed.D.
Educational Administration and Supervision	Ed.D.
Guidance and Personnel Services	Ed.D.
Higher Education Administration	Ed.D.
Industrial Arts Education	Ed.D.
Mathematics Education	Ph.D.
Occupational Education*	Ed.D.
Psychology	Ph.D.
Science Education	Ph.D.

All doctoral programs require a minimum of one year of full-time resident study.

Graduate programs are planned by the student and his or her committee in terms of the student's educational and career objectives, experience and previous preparation.

Prior to consideration of an application for admission, the following must have been received: completed application form, an official copy of current (not more than three years old) Graduate Record Examination (GRE) scores or Miller Analogies Test score, official transcripts of all undergraduate and graduate courses taken and at least three completed recommendation forms. In most programs an interview is required. Psychology requires both the GRE Advanced Test and the Miller Analogies Test. Individual programs may have additional requirements for admission. In order to maintain personalized, quality graduate programs, each program can enroll only a limited number of students regardless of the qualifications of the applicants.

The College of Education and Psychology is housed in Poe Hall, a modern building with up-to-date research and instructional facilities, including:

Curriculum Materials Center—The Curriculum Materials Center, administered by the College of Education and Psychology, is located in Poe Hall. The center maintains a collection of educational materials with particular emphasis on teaching methods, research, administration and psychology and includes films, filmstrips, slides, audiotapes, video cassettes and simulation games. A special collection of materials about developing nations is also maintained. Audiovisual equipment is available for previewing materials in the center. Microcomputers for teaching and research are a part of this facility. The center acquires textbooks adopted by the State Board of Education for secondary level subjects as well as other selected textbooks and reference materials. The mission of the center is to support programs in the College of Education and Psychology, and the center's use by campus personnel outside of the College is limited.

Instructional Materials Production Center—Education, instruction and communication require the clear and effective presentation of content. The Instructional Materials Production Center (IMPC) aids this requirement through the design and production of instructional and informational materials in a range of formats. Although resources and personnel of the IMPC predominantly serve

*Students in agricultural education or industrial and technical education would seek the Ed.D. in occupational education.

faculty, students and projects of the the College of Education and Psychology, increasing requests for materials from the University and beyond are met as possible on a contract basis.

The IMPC is directed by two instructional designers, faculty members of the College of Education and Psychology which is unique in having a production facility in which two persons of such training function full time as designers, producers and consultants. Other personnel in the facility serve as teaching assistants, graphic designers or are hired for the special needs of certain projects. Personnel work through the process of instructional design with those persons having a communicational need—faculty members, content specialists or project directors. Careful application of this process is necessary in order to determine what materials and strategies best serve the interrelated considerations of goals, objectives, content, users, audience, cost and available resources and is also necessary if final products are to be as lucid in design as in educational soundness. Formats in which materials are developed include: print, overhead transparencies, graphic imagery, displays and exhibits, signage, photography, slides, slide-tape presentations and in some cases videotape.

Office of Publications—This office prints and publishes instructional materials developed by faculty and students, as well as by public school teachers associated with various School programs.

The Computing Facility is a laboratory and two adjacent classrooms equipped with microcomputers and with terminals and televideos linked to University computing facilities and the Triangle Universities Computing Center (TUCC). The facility is used for faculty research and development, student projects, graphics instruction, in-service teacher training workshops and training.

Other Special Facilities—Poe Hall also houses an extensive variety of shops (metal, wood, ceramic, electrical and photography); counseling and testing centers; several laboratories for the study of human behavior; an animal room; and a standardized test library.

Adult and Community College Education

Adult and community college education is a component of both the College of Education and Psychology and the College of Agriculture and Life Sciences. For a listing of graduate faculty and departmental information, see adult and community college education.

Agricultural Education

GRADUATE FACULTY

Associate Professor L. R. Jewell, *Coordinator*

Professor: J. K. Coster; *Professor Emeritus:* C. C. Scarborough; *Associate Professors Emeriti:* C. D. Bryant, T. R. Miller; *Assistant Professors:* J. L. Flowers, B. J. Malpiedi

The agricultural education program offers study leading to the Master of Science and the Master of Education degrees and to the intermediate (sixth-year)

certificate. Both master's programs require a minimum of 36 semester hours which reflect the student's background and career expectations and which meet the approval of the student's advisory committee. Graduate programs are designed to meet the needs of individual students for further study and research as well as to prepare them for educational leadership roles in teaching, administration, supervision and research in agricultural education.

FOR GRADUATES AND ADVANCED UNDERGRADUATES

ED 554 Planning Programs in Agricultural Education. 3(3-0) F,S.

ED 565 Agricultural Occupations. 3(3-0) F,S.

ED 566 Occupational Experience in Agriculture. 3(3-0) F,S.

ED 568 Adult Education in Agriculture. 3(3-0) F,S.

FOR GRADUATES ONLY

ED 664 Supervision in Agricultural Education. 3(3-0) F,S.

Counselor Education

GRADUATE FACULTY

Professor D. C. Locke, Head

Professors: E. R. Gerler Jr., L. K. Jones, N. A. Sprinthall; *Professors Emeriti:* W. E. Hopke, C. G. Morehead; *Associate Professor:* H. A. Exum; *Visiting Associate Professor:* T. H. Stafford Jr.; *Associate Professor Emeriti:* J. G. McVay, B. C. Talley Jr.; *Assistant Professor:* D. D. Saidla; *Visiting Assistant Professor:* C. L. Oglesby; *Adjunct Assistant Professor:* R. F. Anderson

The department offers work leading to the Master of Science, Master of Education and Doctor of Education degrees as well as to the sixth-year certificate, with a major in the field of guidance and personnel services. Each of these degrees is designed to prepare individuals for guidance and personnel positions at various levels in elementary and secondary schools, junior and community colleges, trade and technical schools and institutes, institutions of higher education and community agencies. The student may specialize in one of several areas depending upon individual career goals.

It is desirable for an applicant to have had undergraduate or graduate course work in humanities, social and behavioral sciences as well as work experience in a human development context. Students accepted into the department are those who anticipate devoting full- or part-time to guidance and personnel work.

Admission requirements for the department are a minimum of a B average in the junior and senior years of undergraduate work; satisfactory scores on the aptitude section of the Graduate Record Examination or the Miller Analogies Test; three satisfactory letters of recommendation in regard to previous education and employment experiences, personal characteristics and emotional

maturity. An interview and work sample are also required for doctoral admission.

For descriptions of the guidance and personnel courses listed below, see education courses.

FOR GRADUATES AND ADVANCED UNDERGRADUATES

ED 520 Introduction to Counseling. 3(3-0) *F, Sum.*

ED 521 Internship in Guidance and Personnel Services. *Credits Arranged. F, S.*

ED 524 Career Counseling and Development. 3(3-0) *S, Sum.*

ED 530 Theories and Techniques of Counseling. 3(3-0) *F, S, Sum.*

ED 533 Guidance and Counseling in the Secondary Schools. 4(3-1) *F.*

ED 534 Guidance and Counseling in Elementary and Middle Schools. 4(3-1) *F.*

ED 535 Student Personnel Work in Higher Education. 3(3-0) *F.*

ED 553 Community Service Agencies. 3(3-0) *F.*

ED 590 Special Problems in Guidance. *Maximum 6 F, S.*

FOR GRADUATES ONLY

ED 625 Cross Cultural Counseling. 3(3-0) *S.*

ED 631 Vocational Development Theory. 3(3-0) *F. Alt. yrs.*

ED 636 Observation and Supervised Field Work. 1-3 *F, S.*

ED 637 Seminar in Cognitive-Developmental Theory and Practice. 3(3-0) *F. Alt. yrs.*

ED 638 Seminar in Cognitive-Developmental Research. 3(3-0) *S. Alt. yrs.*

ED 639 Group Counseling. 3(3-0) *F, Sum.*

ED 640 Laboratory Experiences in Counseling. 3(3-0) *F.*

ED 641A Practicum in Counseling. 2-6 *S.*

ED 666 Supervision of Counseling. 3(1-8) *F, S.*

ED 686 Professional Issues in Counseling. 1-3 *F, S, Alt. yrs.*

Curriculum and Instruction

GRADUATE FACULTY

Professor C. L. Crossland, Head

Professors: D. A. Cullinan, P. H. Martorella, B. M. Parramore; *Associate Professors:* J. F. Arnold, B. J. Fox, C. W. Harper Jr., R. J. Pritchard, L. Thies-Sprinthall, E. S. Vasu; *Professor Emeritus:* C. C. Scarborough; *Associate Professor Emeritus:* P. J. Rust; *Assistant Professors:* C. A. Pope, H. A. Spires; *Visiting Assistant Professor:* L. G. Aubrecht; *Adjunct Assistant Professors:* D. D. Copeland, M. D. Durfee, N. D. LeVere; *Assistant Professor Emeritus:* K. A. McCutchen

The department offers work leading to the Master of Education, Master of Science and Doctor of Education degrees. A sixth-year program leading to certification is also available. Those completing the master's program may qualify for a graduate teaching certificate in an area of specialization or for a supervisor's certificate.

Students may specialize in one of several areas:

- Curriculum development and supervision
- English and language arts education
- Elementary education—intermediate grades
- Instructional technology—computers
- Middle years education
- Reading education
- Social studies education
- Special education
- Supervision

Graduate programs are designed for those who plan to qualify as supervisors, instructional specialists, curriculum developers, teacher educators and consultants at preschool through university levels. Graduates may enter positions in public schools, service agencies, higher education institutions and industries.

In addition to meeting the requirements of the Graduate School, applicants must provide evidence of satisfactory scores on the Graduate Record Examination and/or Miller Analogies Test; submit a written statement of professional goals; and arrange for a departmental interview upon request.

SELECTED ADVANCED UNDERGRADUATE COURSE

ED 483 *An Introduction to Instructional Media. Preq.: Advanced undergrad. standing. 3(3-0) F,S,Sum.*

FOR GRADUATES AND ADVANCED UNDERGRADUATES

ED 501 *Computer Applications in Instruction. 3(3-0) F,S.*

ED 502 *The School Curriculum. 3(3-0) F.*

ED 504 *Social Studies in the Elementary School. 3(3-0) F.*

- ED 506** Education of Exceptional Children. *3(3-0) F.*
- ED 507** Foundations of Middle Years Education. *3(3-0) F.*
- ED 508** Education of Severely Handicapped. *3(3-0) F.*
- ED 509** Methods and Materials Teaching Retarded Children. *3(3-0) S.*
- ED 513** Introduction to Issues and Techniques in Visual Impairments. *3(3-0) F.*
- ED 519** Early Childhood Education. *3(1-4) S.*
- ED 523** Orientation and Mobility of the Visually Impaired. *3(3-0) F.*
- ED 531** Mental Retardation. *3(3-0) F.*
- ED 536** Structure and Function of the Eye and Use of Low Vision. *3(3-0) F.*
- ED 540** Career/Vocational Education for the Handicapped. *3(3-0) S.*
- ED 542** Contemporary Approaches in the Teaching of Social Studies. *3(3-0) S.*
- ED 544** The Teaching of Composition. *3(3-0) S.*
- ED 545** Reading in the Elementary School. *3(3-0) F. Alt. yrs.*
- ED 546** Reading in the Content Areas. *3(3-0) S, Sum.*
- ED 547** Language Arts in the Elementary School. *3(3-0) S.*
- ED 548** Development of Microcomputer Software for Instruction. *3(3-1) F.*
- ED 551** Principles and Practices of Supervision. *3(3-0) S.*
- ED 556** Learning Disabilities. *3(3-0) F.*
- ED 557** Methods and Materials in Learning Disabilities. *3(3-0) S.*
- ED 558** Resource Teaching in Special Education. *3(3-0) F.*
- ED 560** Teaching Through the Arts. *3(3-0) S.*
- ED 561** Educational Diagnosis and Prescription for Exceptional Children. *3(3-0) S.*
- ED 562** Communication Disorders in the Classroom. *3(3-0) S. Alt. yrs.*
- ED 563** Effective Teaching. *3(3-0) F.*
- ED 564** Classroom Management in Special Education. *3(3-0) S.*
- ED 571** Introduction to the Gifted Individual. *3(3-0) F.*
- ED 572** Methods for Teaching the Gifted. *3(3-0) S.*
- ED 573** Behavior Disorders. *3(3-0) F.*
- ED 574** Methods and Materials Behavior Disorders. *3(3-0) S.*
- ED 576** Teaching/Learning Approaches for Emerging Adolescents. *3(3-0) S.*

- ED 582 Teaching Braille and Communication Skills. 3(3-0) S.
 ED 583 Design and Evaluation of Instructional Materials. 3(3-0) S.
 ED 586 Methods and Materials in Visual Impairments. 3(3-0) S.
 ED 591 Teaching Literature for Young Adults. 3(3-0) S. Alt. yrs.
 ED 598 Special Problems in Curriculum and Instruction. 1-6 F,S,Sum.

FOR GRADUATES ONLY

- ED 602 Curriculum Theory and Development. 3(3-0) F.
 ED 606 Remediation of Reading Disabilities. 3(3-0) S. Alt. yrs.
 ED 634 Diagnosis of Reading Disabilities. 3(3-0) F. Alt. yrs.
 ED 641B Diagnostic-Prescriptive Practicum in Reading. 3(3-0) S.
 ED 641C Practicum in Special Education. 1-6 F,S.
 ED 641G Practicum in Middle Years Education. 3-6 F,S.
 ED 641K Practicum in Supervision. 3-6 F,S.
 ED 641M Practicum in Instructional Technology—Computers. 3-6 F,S.
 ED 642 Research Applications in Curriculum and Instruction. 3(3-0) S.
 ED 648 Theory and Process in Reading and Language Arts. 3(3-0) S. Alt. yrs.
 ED 665 Supervising Student Teachers. 3(3-0) F,S.
 ED 687 Seminar in Curriculum and Instruction. 1-3 S.

Educational Leadership and Program Evaluation

GRADUATE FACULTY

Professor R. G. Taylor Jr., *Head*

Professors: B. G. Beezer, C. J. Dolce; *Adjunct Professors:* C. R. Coble, A. A. Glatthorn; *Associate Professors:* W. B. Harvey, B. MacPhail-Wilcox, R. C. Serow; *Visiting Associate Professor:* R. H. Forbes; *Adjunct Associate Professor:* J. S. Pressley; *Visiting Assistant Professor:* J. I. Dreyden; *Lecturer:* R. T. Williams

The graduate programs in educational administration and supervision have a multidisciplinary emphasis which includes courses in economics, politics, psychology and sociology as well as in professional education. Within the constraints required for certification, programs are planned individually, based on an analysis of the student's career objectives and competencies.

The master's degree programs (M.S., M.Ed.), which require a minimum of 30 or 36 credit hours, are designed to prepare individuals for entry-level adminis-

trative positions in public schools, colleges and other educational agencies. The master's program must be completed within four years from the semester of admission. A principal's certificate program is available for students who already hold a master's degree in a related field and who wish to obtain a first administrative credential for public school service. An intermediate (sixth-year certificate) program, which leads to the second level of certification, is also available for public school personnel.

The doctoral degree program (Ed.D.), which requires extensive work in research and clinical practice (internship), is designed to prepare individuals for advanced administrative and supervisory positions in public schools, education service agencies, education policy positions and higher education. One academic year of full-time residency is required. The doctoral program must be completed within six years from the semester of admission. In addition, an Ed.D. degree in elementary and secondary administration is offered in Greenville, NC, in cooperation with East Carolina University.

In addition to admission requirements of the Graduate School, there are two additional requirements: a recent Graduate Record Examination score (both verbal and quantitative) or a Miller's Analogy Test and a narrative statement which describes in detail the applicant's career objectives and specific objectives for enrolling in the graduate program.

FOR GRADUATES AND ADVANCED UNDERGRADUATES

ED 514 Formative Ideas in American Education. 3(3-0) *F*.

ED 515 Education and Social Diversity. 3(3-0) *Alt. yrs.*

ED 517 Current Issues in Higher Education. 3(3-0) *F. Alt. yrs.*

ED 518 Introduction to Education Law. 3(3-0) *F*.

ED 532 Introduction to Educational Inquiry. 3(3-0) *F,S,Sum.*

ED 541B Practicum in Education Administration. 1-6 *F,S,Sum.*

ED 550 Principles of Educational Administration. 3(3-0) *F,S.*

ED 569 The Principalship. 3(3-0) *S. Alt. yrs.*

ED 578 Law and Higher Education. 3(3-0) *S. Alt. yrs.*

ED 580 Evaluation Theory and Practice in Education. 3(3-0) *F*.

FOR GRADUATES ONLY

ED 607 The Politics of Higher Education. 3(3-0) *S.*

ED 614 Contemporary Educational Thought. 3(3-0) *Alt. yrs.*

ED 616 History of Higher Education in the United States. 3(3-0) *F. Alt. yrs.*

ED 618 School Law for the Administrator. 3(3-0) *S. Alt. yrs.*

ED 620 Cases in Educational Administration. 3(3-0) *Alt. yrs.*

ED 632 Applied Research Methods in Education. 3(1-4) F.

ED 697 Problems of Research Design in Education. 1-3 F,S,Sum.

Industrial and Technical Education

GRADUATE FACULTY

Associate Professor E. I. Farmer, Coordinator

Professors Emeriti: D. M. Hanson, J. T. Nerden; *Associate Professor Emeritus:* F. S. Smith; *Assistant Professor Emeritus:* T. C. Shore Jr.

The program in industrial and technical education provides graduate work leading to the degrees of Master of Science and Master of Education and to the intermediate (sixth-year) certificate in vocational industrial education. The rapid development of industrial and technical education in North Carolina and throughout the nation provides opportunities for teachers, supervisors and administrators who have earned advanced degrees.

The facilities at the University allow supporting courses at the graduate level in the related fields of computer science, economics and business, engineering, guidance and personnel services, mathematics, psychology, sociology and statistics. The prerequisite for graduate work in the programs in industrial and technical education is a proficiency in the undergraduate courses required for the bachelor's degree in industrial or technical education or a substantial equivalent.

SELECTED ADVANCED UNDERGRADUATE COURSES

ED 421 Principles and Practices in Industrial Cooperative Training. *Preqs.: ED 327, 344, 305. 3(3-0) F.*

FOR GRADUATES AND ADVANCED UNDERGRADUATES*

ED 525 Advanced Trade Analysis and Course Construction. 3(3-0) F.

FOR GRADUATES ONLY

ED 609 Planning and Organizing Industrial and Technical Education Programs. 3(3-0) F.

Industrial Arts Education

GRADUATE FACULTY

Associate Professor R. E. Peterson, Coordinator

Professors: B. G. Beezer, C. J. Dolce; *Visiting Professor:* A. A. Glatthorn; *Adjunct Professors:* V. W. DeLuca, W. J. Haynie III

*For other courses, see occupational education.

The industrial arts education program offers graduate work leading to the degrees of Master of Science, Master of Education and Doctor of Education. Graduate programs are designed for teachers who wish to develop their instructional competencies and for those who wish to be supervisors and administrators of industrial arts programs.

FOR GRADUATES AND ADVANCED UNDERGRADUATES

IA 510 Design for Industrial Arts Teachers. *Preqs.: Six hours of drawing, IA 231 or equivalent. 3(2-2) Sum.* A study of new developments in the field of design with emphasis on the relationship of material and form in the selection and designing of industrial arts projects.
Graduate Staff

IA 560 New Developments in Industrial Arts Education. *Preqs.: Twelve hours of education and teaching experience. 3(3-0) F,S,Sum.* This course is a study of the new developments in industrial arts education. It is designed to assist teachers and administrators in developing new concepts and new content based on the changes in technology.
Graduate Staff

IA 582 Visual Communications in Industrial Arts Education. *Preq.: Advanced standing in IAE or CI. 3(2-2) S. Alt. yrs.* Designed to enable teachers to understand key technical developments in the area of visual communications. Emphasis is upon developing pilot testing and evaluating a sequence of laboratory activities for school environment.
Peterson

ED 588 Advanced Teaching Methods in Industrial Arts Education. *3(2-2) F,Sum.*

IA 590 Laboratory Problems in Industrial Arts. *Preqs.: Sr. standing, CI. Maximum 6. F,S,Sum.* Courses based on individual problems and designed to give advanced majors in industrial arts education the opportunity to broaden or intensify their knowledge and abilities through investigation and research in the various fields of industrial arts, such as metals, plastics, ceramics or electricity-electronics.
Graduate Staff

FOR GRADUATES ONLY

ED 630 Philosophy of Industrial Arts. *2(2-0) F,S.*

ED 635 Administration and Supervision of Industrial Arts. *2(2-0) F,S.*

IA 645 Technology and Industrial Arts. *Preqs.: IA 560, ED 630. 3(3-0) F,S.* Technology: its nature, origins, advance. Impact of technological advance on man and culture. Technology as the material culture. Changing concepts of work, skill, occupations, discretionary time. Technology and its relation to industrial arts education.
Graduate Staff

ED 692 Seminar in Industrial Arts Education. *1(1-0) F,S.*

Mathematics and Science Education

GRADUATE FACULTY

Professor B. G. Beezer, Acting Head

Professors: N. D. Anderson, L. M. Clark, J. R. Kolb; *Professor Emeritus:* H. E. Speece; *Associate Professors:* L. V. Stiff, W. M. Waters Jr., L. W. Watson, J. H. Wheatley; *Associate Professor Emeritus:* H. A. Shannon; *Assistant Professors:* K. S. Norwood, J. C. Park; *Visiting Assistant Professor:* S. B. Berenson

The Department of Mathematics and Science Education offers graduate work leading to the degrees of Master of Science, Master of Education and Doctor of Philosophy with majors in mathematics education or in science education and intermediate level certification in both fields. Each student's program is individually planned by a graduate committee and will reflect the student's undergraduate and graduate preparation, teaching experience and future professional plans. Students take courses in both professional education and in their teaching specialties. Areas of specialization include mathematics, biological sciences, earth science, chemistry and physics.

Doctoral students are required to have a reading knowledge of one modern foreign language. Additional communication skills may be required by the advisory committee. Independent reading and participation in seminars are an indispensable part of the doctoral program. The heart of the program is the dissertation, a document based on original research that makes a significant contribution to science education or mathematics education.

Applicants must meet the admissions requirements of the Graduate School and have departmental approval.

FOR GRADUATES AND ADVANCED UNDERGRADUATES

ED 511 Implications of Mathematical Content, Structure, and Processes for the Teaching of Mathematics in the Elementary School. 3(3-0) S,Sum. Alt. yrs.

ED 512 Teaching Mathematics in Elementary and Junior High School. 3(3-0) S,Sum. Alt. yrs.

ED 526 Teaching in College. 3(3-0) Sum.

ED 570 Foundations of Mathematics Education. 3(3-0) S,Sum. Alt. yrs.

ED 575 Foundations of Science Education. 3(3-0) S,Sum., Alt. yrs.

ED 577 Improving Classroom Instruction in Science. 3(3-0) S.

ED 592 Special Problems in Mathematics Teaching. 1-3 F,S,Sum.

ED 594 Special Problems in Science Teaching. 1-6 F,S,Sum.

FOR GRADUATES ONLY

ED 603 Teaching Mathematics and Science in Higher Education. 3(3-0) S.

ED 604 Curriculum Development and Evaluation in Science and Mathematics. 3(3-0) S.

ED 605 Education and Supervision of Teachers of Mathematics and Science. 3(3-0) S.

ED 641D Practicum in Science and Mathematics Education. 1-6 F,S.

ED 690 Seminar in Mathematics Education. 2(2-0) F,S.

ED 695 Seminar in Science Education. 2(2-0) F,S.

Occupational Education

GRADUATE FACULTY

Professor G. E. Moore, Head

Associate Professor: L. R. Jewell, Graduate Administrator

Professor: J. K. Coster; Professors Emeriti: D. M. Hanson, J. T. Nerden, D. W. Olson, C. C. Scarborough; Associate Professors: J. L. Burrow, L. S. Dillon, E. I. Farmer, R. E. Peterson, R. E. Wenig; Associate Professors Emeriti: C. D. Bryant, J. R. Clary, W. L. Cox Jr., T. R. Miller, F. S. Smith; Assistant Professors: J. L. Crow, J. A. Davis, V. W. DeLuca, J. L. Flowers, W. J. Haynie III, B. J. Malpiedi, R. M. Patterson, W. J. Vander Wall; Visiting Assistant Professor: M. M. Turnbull; Adjunct Assistant Professors: C. B. Belcher, B. M. Patterson; Assistant Professor Emeritus: T. C. Shore Jr.

The Department of Occupational Education includes programs leading to advanced degrees in the program areas of agricultural education, health occupations education, industrial and technical education, and industrial arts education. For descriptions of the advanced degree programs in these areas, see earlier sections in education. In addition, the department offers advanced degree programs in occupational education and courses leading to certification in the teaching of middle grades occupational exploration.

This section of the catalog describes the advanced programs in occupational education *per se*; that is, programs in which the major is occupational education. The department offers leadership development programs in occupational education for the Master of Education and Master of Science degrees, the Intermediate (Sixth-Year) Program, and Doctor of Education degree.

The master's programs are designed to prepare persons for entry-level administrative and supervisory positions in occupational education. However, students may prepare for other careers, such as master teachers of career exploration programs.

The master's programs require a minimum of 36 semester hours of graduate work, including 27 hours in the major. Additional hours will be specified by the student's advisory committee for those who do not have a baccalaureate degree in an occupational education field. Students who elect the Master of Science substitute the thesis for part of the course load.

The Intermediate (Sixth-Year) Program requires a minimum of 60 semester hours of graduate work, including 48 hours in the major.

The primary purpose of the doctoral program is to prepare persons for advanced positions in occupational education. Students may elect to prepare for such positions as administrator, research specialist, curriculum development specialist or teacher educator in occupational education. A minimum number of 90 semester hours of graduate work beyond the baccalaureate degree is specified for the doctoral program. Emphasis is placed on developing competencies, and students may be advised to supplement their course work.

Applicants to the graduate level programs must take the Graduate Record Examination or the Miller Analogies Test and submit a resume of work experience.

rience with a statement of career goals. Application processes must be completed within six months of the date the application is received.

All doctoral programs require a minimum of one year of full-time resident status devoted to the program and programs must be completed within six years from the beginning of the semester in which the student is initially enrolled in the doctoral classification. Other department policies should be requested from the graduate administrator.

FOR GRADUATES AND ADVANCED UNDERGRADUATES

ED 516 Analysis of Occupational Information, Trends and the Labor Market. 3(3-0) S.

ED 522 Career Exploration. 3(3-0) F,S,Sum.

ED 527 Philosophy of Occupational Education. 3(3-0) F,S.

ED 528 Cooperative Occupational Education. 3(3-0) F,S.

ED 529 Curriculum Materials Development. 3(3-0) F,S.

ED 541A Practicum in Occupational Education. 1-6 F,S.

ED 593 Special Problems in Occupational Education. 1-6 F,S,Sum.

FOR GRADUATES ONLY

ED 609 Planning and Organizing Industrial and Technical Education Programs. 3(3-0) F. Alt. yrs.

ED 611 Laws, Regulations and Policies Affecting Occupational Education. 3(3-0) S.

ED 612 Finance, Accounting, and Management of Occupational Education Programs. 3(3-0) S. Alt. yrs.

ED 688 Research Application in Occupational Education. 3(3-0) F,S.

ED 693 Advanced Special Problems in Occupational Education. 1-6 F,S,Sum.

Health Occupations Education

Assistant Professor J. A. Davis, Coordinator

The master's degree level program track in health occupations teacher education has been established in response to an increasing need for accountability in professional education and for qualified educators in the health fields. The program is designed to provide a broad comprehension of the health care delivery system and the education of future providers of service and to develop competency in curriculum and instruction planning and implementation. Students desiring to move into administrative and supervisory roles are encouraged to design a plan of study consistent with their personal goals. Students must hold credentials in one of the health disciplines and have knowledge of the health care system.

Students will be encouraged to participate in the interinstitutional cooperative program that exists between the Graduate Schools of North Carolina State

University, Duke University and the University of North Carolina at Chapel Hill which makes available a vast array of offerings in the health field from which to select courses.

SELECTED ADVANCED UNDERGRADUATE COURSE

ED 433 Health Occupations Specialty Practicum. *Preq.: Current credential in a recognized health discipline. 6 Arranged. F,S.*

FOR GRADUATES AND ADVANCED UNDERGRADUATES

ED 555 Issues and Trends in Education for the Allied Health Professions. *3(3-0) Alt. yrs.*

ED 581 Curriculum and Instruction in the Allied Health Professions. *3(3-0) Alt. yrs.*

ED 584 Health Care Delivery Systems and Environments. *3(3-0) Alt. yrs.*

FOR GRADUATES ONLY

ED 641J Practicum in Health Occupations. *3(3-0) Alt. yrs.*

Training and Development

Associate Professor L. S. Dillon, Coordinator

Human resource development is a field which deals with the quality of work life, productivity and the satisfaction and development of human resources. Within this field, nine distinct areas may be defined: organization development, organization and job design, planning, selection and staffing, personnel research, compensation and benefits, employee assistance, union and labor relations, and training and development. The focus of training and development is to identify and, through planned learning activities, help to develop the key competencies which enable individuals to perform current or future jobs.

Students may pursue either the Master of Education or the Master of Science degree. Both degrees require a minimum of 36 hours.

FOR GRADUATES AND ADVANCED UNDERGRADUATES

ED 587 Organization and Operation of Training and Development Programs. *3(3-0) F.*

ED 595 Methods and Techniques of Training and Development. *3(3-0) S.*

Psychology

For a listing of departmental faculty and courses, see psychology.

Education Courses

FOR GRADUATES AND ADVANCED UNDERGRADUATES

ED 500 Community College and Two-year Postsecondary Education. *Preq.: Grad. standing or PBS status. 3(3-0) F,S.* Comprehensive community colleges and technical institutes and the state systems of which they are a part: underlying concepts, educational needs they are designed to serve, role in meeting these needs, historical development, issues in the establishment and operation of state systems and individual institutions, unresolved issues and emerging trends. Graduate Staff

ED 501 Computer Applications in Instruction. *Preq.: Six hrs. ED or PSY or CI. 3(3-0) F,S.* Emphasis on the use and evaluation of existing educational software and research findings with respect to the uses of computers in instruction. Martorella, Vasu

ED 502 The School Curriculum. *Preq.: 12 semester hrs. ED and PSY or CI. 3(3-0) F.* A study of the origin, development, and current status of the elementary and secondary school curriculum and an evaluation of the trends and issues likely to influence the curriculum in the future. Parramore

ED 503 The Programming Process in Adult and Community College Education. *Preq.: Grad. standing. 3(3-0) F,S.* The principles and processes involved in programming, including basic theories and concepts supporting the programming process. Attention given to the general framework in which programming is done, the organization needed and the program roles of both professional and lay leaders. Boone

ED 504 Social Studies in the Elementary School. *Preq.: Six hrs. in ED. 3(3-0) F.* Advanced professional training in the teaching of social studies for middle grades and elementary teachers, including an in-depth introduction to research-based teaching strategies, instructional resources and the literature of the field. Martorella

ED 505 Group Process in Adult and Community College Education. *Preq.: Grad. standing or PBS status. 3(3-0) Sum.* Application of research and theory in small group behavior to administration and teaching in adult and community college education settings. Opportunities provided for participants to experience various aspects of group behavior and to practice skills of group leadership applicable to various group situations. Graduate Staff

ED 506 Education of Exceptional Children. *Preq.: 9 hrs. of ED or PSY. 3(3-0) F,S,Sum.* An introduction to the field of Special Education. The course focuses on the historical overview, definitions and terminology in the basic areas of exceptionality; etiological factors in exceptionality; developmental and learning characteristics of each area of exceptionality; and educational settings and strategies employed in special education. A review given of current educational laws and policies affecting special education. Graduate Staff

ED 507 Foundations of Middle Years Education. *Preq.: 6 hrs. of ED and PSY. 3(3-0) F,S.* Five major aspects of middle years education examined: (a) the history and purposes of middle/junior high school, (b) pre- and early adolescent needs, interests and abilities, (c) curriculum design and content, (d) teaching methods and (e) school organization. Both theoretical understandings and effective classroom strategies emphasized. Arnold

ED 508 Education of Severely Handicapped. *Preq.: ED 531 or ED 574 or CI. 3(3-0) F.* A study of severe and profound mental retardation and autism, including assessment procedures, educational and social/vocational programs, instructional strategies and evaluation. Legal and ethical issues involved in working with the severely handicapped examined. Graduate Staff

ED 509 Methods and Materials—Teaching Retarded Children. *Preqs.: ED 506 and ED 531 or CI. 3(3-0) S.* A study of the methods and materials related to teaching mentally retarded school age children. Course includes the study of the learning and behavioral characteristics and educational programs for the mentally retarded in the areas of motor, communications, social, academic and vocational development. Crossland

ED 510 Adult Education: History, Philosophy, Contemporary Nature. *Preqs.: Advanced undergrad., CI. 3(3-0) F,S.* A study of the historical and philosophical foundations of adult education from ancient times to the present, giving attention to key figures, issues, institutions, movements and programs, including consideration of the relationship between adult education's historical development and prevailing intellectual, social, economic and political conditions. Consideration of adult education's contemporary nature, present-day schools of thought on its objectives and trends. Carter

ED 511 Implications of Mathematical Content, Structure, and Processes for the Teaching of Mathematics in the Elementary School. *Preq.: Bachelor's degree in elementary education or CI. 3(3-0) S,Sum. Alt. yrs.* Designed for teachers and supervisors of mathematics in the elementary or middle school. Special emphasis on implications of mathematical content, structure, and processes in teaching arithmetic and geometry. Waters, Watson

ED 512 Teaching Mathematics in Elementary and Junior High School. *Preq.: ED 471 or equivalent. 3(3-0) S,Sum. Alt. yrs.* Comprehensive study of teaching mathematics in elementary and junior high schools. Major emphasis on building skills in teaching arithmetic, elementary algebra and intuitive geometry. Thorough search of the literature relative to the mathematics curricula conducted, designing and sequencing of learning activities, teaching mathematical concepts and relationships, building skill in computation, reading mathematics, problem solving and measurement covered. Kolb, Watson

ED 513 Introduction to Issues and Techniques in Visual Impairments. *Preq.: ED 506. 3(3-0) F.* Addresses historical developments, trends, issues and basic skill techniques for the visually impaired. Includes societal perceptions, societal integration, effects of a visual impairment on development, psychosocial adjustment and Braille transcription skills. Graduate Staff

ED 514 Formative Ideas in American Education. *Preq.: Six hrs. ED or PSY or CI. 3(3-0) F.* A consideration of the theory and practice of American education as an extension of the philosophical climate of opinion of different intellectual ages and how the present status of our educational system is grounded in the thought of the past. Beezer

ED 515 Education and Social Diversity. *Preq.: Six hrs. ED, PSY and/or social science. 3(3-0) Alt. S.* An overview of the role of education within a culturally diverse society. Major attention directed to racial, ethnic, socioeconomic and regional subpopulations. Among the issues to be discussed: the subcultural influences on public school performances, equality of educational opportunity, social stratification and mobility and the impact of schooling on intergroup relations. Serow

ED 516 Analysis of Occupational Information, Trends and the Labor Market. *Preq.: Six hrs. of ED. 3(3-0) S.* Overview of federal, state and local sources of labor market information. Analysis of labor market concepts and applications for career exploration and decision making. Use of community surveys in vocational program planning. Graduate Staff

ED 517 Current Issues in Higher Education. *Preq.: Grad. standing or PBS status. 3(3-0) F. Alt. yrs.* Examines important social, political and economic issues that affect the present and future operation of colleges and universities in America. Graduate Staff

ED 518 Introduction to Education Law. *Preq.: Six hrs. graduate credit. 3(3-0) S.* A study of constitutional, statutory and case law as it relates to the elementary and secondary public school settings, particularly in the areas of students, teachers and liability. Particular emphasis placed on North Carolina and federal law. Beezer

ED 519 Early Childhood Education. *Preq.: PSY 475 or PSY 576. 3(1-4) S.* Planning, selecting and using human resources, activities, materials and facilities in the education of young children. Student observation, participation and evaluation of educational experiences for the developmental level of individual children for an optimum learning environment. A synthesis of the student's knowledge of human development, learning theory and research findings as related to classroom application. Graduate Staff

ED 520 Introduction to Counseling. *Preq.: Six hrs. in ED or PSY. 3(3-0) F,S,Sum.* An introduction to counseling with a focus on three settings—schools, college and community agencies. Designed to explore issues of theory, practice and research with regard to children, adolescents, college students and adults. Personal and professional exploration encouraged through the use of psychological tests. Graduate Staff

ED 521 Internship in Guidance and Personnel Services. *Preqs.: Eighteen hrs. in department and CI. Credits Arranged. F,S.* A continuous full-time internship of at least one-half semester. Framework of school and community. Work with students, teachers, administrators, guidance and pupil personnel workers, parents and resource personnel in the community. Supervision of intern by guidance personnel in school as well as by course instructors. Graduate Staff

ED 522 Career Exploration. *Preq.: 12 hrs. ED or CI. 3(3-0) F,S,Sum.* This course is designed for teachers in the public schools of North Carolina who teach in "Career Exploration" programs. The course emphasizes the philosophy of career exploration, theories supporting career exploration, the place of exploration programs in the overall school curriculum, correlation of occupational information in academic subjects, sources of occupational information and its use and approaches to teaching in a career exploration program. Clary, Dillon

ED 523 Orientation and Mobility of the Visually Impaired. *Preq.: CI. 3(3-0) F.* The sensory processes and sensory cues on which independent mobility depends for the visually impaired person. Various techniques and modes of travel considered. Emphasis given to instruction and background which will enable person not teaching orientation mobility as a skill to reinforce the learning taking place in other situations. Graduate Staff

ED 524 Career Counseling and Development. *Preq.: Six hrs. of ED or PSY. 3(3-0) S,Sum.* Knowledge and skills needed to: (a) provide professional career counseling to individuals and (b) design, implement and evaluate career development programs for particular groups. Areas of study include: theories of career development and decision making; career guidance programs in educational, agency and industrial setting; career information sources and delivery systems; and assessment in career counseling. Gerler, Jones

ED 525 Advanced Trade Analysis and Course Construction. *Preq.: 12 hrs. ED or CI. 3(3-0) F.* Principles and practices in analyzing occupations for the purpose of determining teaching content. Practice in the principles underlying industrial course organization based on occupational analysis covering instruction skills and technology and including course outlines, job sequences, the development of industrial materials and instructional schedules. Graduate Staff

ED 526 Teaching in College. *3(3-0) Sum.* This course focuses on the development of competencies to perform the fundamental tasks of a college teacher as well as consideration of more long-range tasks such as course development and the university responsibilities of a professor. In addition to attending lectures and other types of presentations, students make video tapes of their teaching, develop tests, design introductory courses in their teaching fields and consider current issues related to university and college teaching. Anderson

ED 527 Philosophy of Occupational Education. *Preq.: 12 hrs. ED or CI. 3(3-0) F,S.* An historical and philosophical investigation into the social and economic aspects of occupational education; an overview of the broad field of occupational education for youth and adults, with emphasis upon the trends and problems connected with the conduct of occupational education under federal and state guidance. An overview study of federal and state legislation pertaining to occupational education. Malpiedi

ED 528 Cooperative Occupational Education. *Preq.: Grad. standing or PBS status. 3(3-0) F,S.* Designed for individuals preparing to be directors, administrators or supervisors of occupational education programs at the local, state and/or national levels. Emphasis on organization and operation of cooperative occupational education programs. Covers the entire field of cooperative occupational education on secondary, postsecondary and adult levels with references to accepted essentials of cooperative education so details of planning, organization, establishment and operation of cooperative occupational programs practical and meaningful. Student visitations to existing quality programs in cooperative occupational education to study on-site conditions in specialized areas. Dillon

ED 529 Curriculum Materials Development. *Preqs.: Grad. standing and ED 527 or ED 630 or equivalent. 3(3-0) S.* Selection and organization of curricula and instructional materials in occupational education. Dillon

ED 530 Theories and Techniques of Counseling. *Preq.: Six hrs. of ED or PSY; Coreq.: ED 520 or equivalent. 3(3-0) F,S,Sum.* A combination of the study of theory and philosophy in counseling with techniques of counseling. Topics to be examined include behavioral approaches, psychoanalytic approaches, client-centered counseling, existential counseling and relationship models, and their relation to counseling. For each theory, the techniques are related to the theoretical concepts and principles. Locke

ED 531 Mental Retardation. *Preq.: ED 506 or CI. 3(3-0) F.* The definitions, classifications, diagnostic and treatment procedures for mental retardation examined from medical, sociological and educational points of view. Categories of retardation examined include mild, moderate, severe and profound. Graduate Staff

ED 532 Introduction to Educational Inquiry. *Preq.: Grad. standing or PBS status. 3(3-0) F,S,Sum.* A survey of basic concepts and methods of educational inquiry. Emphasis on the logic underlying various approaches to problem definition and solution and on the tools of the investigator, as well as on sources and interpretation of research information related to the student's particular area of study. Taylor

ED 533 Guidance and Counseling in the Secondary Schools. *Preq.: Grad. standing. 4(3-1) F.* An examination of (1) theoretical framework for roles and functions of secondary school counselors, (2) primary and secondary prevention strategies and (3) evaluation and administration procedures, to develop and implement model programs for secondary schools. A major focus on career and classroom developmental guidance as opposed to remediation and treatment. Graduate Staff

ED 534 Guidance and Counseling in Elementary and Middle Schools. *Preq.: Grad. standing. 4(3-1) F.* An examination of (1) theoretical framework for roles and functions of elementary and middle school counselors, (2) primary and secondary prevention strategies and (3) evaluation and administration procedures to develop and implement model programs for elementary and middle schools. A major focus will be on classroom developmental guidance as opposed to remediation and treatment. Gerler

ED 535 Student Personnel Work in Higher Education. *Preq.: Nine hrs. PSY or CI. 3(3-0) F.* Examines practices in various areas of student personnel work. Studies both structure and function of student personnel programs in higher education. Saidla

ED 535 Structure and Function of the Eye and Use of Low Vision. *Preq.: CI. 3(3-0) F.* Special institute for participants to spend minimum of 45 hours in class and class-related activities. Medical and educational consultants discuss structure and function of the eye,

eye anomalies affecting children with low vision, methods of teaching children to use minimal vision effectively. Graduate Staff

ED 537 The Extension and Public Service Function in Higher Education. *Preq.: ED 510. 3(3-0) S.* An examination of the background, history, philosophy and contemporary nature of the extension and public service function of institutions of higher education in the United States. Emphasis placed on the adult education role of public and private universities and colleges. Specific focus on: general extension, industrial extension, engineering extension, cooperative extension and continuing education. Graduate Staff

ED 538 Instructional Strategies in Adult and Community College Education. *Preq.: Grad. standing or PBS status. 3(3-0) F.* This course examines forms of instruction appropriate for the teaching of adults. Special emphasis placed upon methods which maximally involve the adult learner. The study of concepts, theories and principles relevant to the selection, utilization and evaluation of instructional strategies focus on the integration of theory into practice. Through participation in classroom exercises, the student develops proficiency in using teaching techniques applicable in adult and community college education. Fingeret

ED 539 Educational Gerontology. *Preq.: Six hrs. in ED, SOC or PSY. 3(3-0) F.* A broad overview of factors associated with the education of older adults. Various sociological, physiological, psychological and economic aspects of aging explored in terms of their educational implications. Attention given to knowledge and skills required for the development of educational programs for the aging population. Glass

ED 540 Career/Vocational Education for the Handicapped. *Preqs.: ED 506 and ED 527 or CI. 3(3-0) S.* Relevant definitions and current legislation and policies reviewed. Appropriate curriculum, methods and materials studied. Topic areas include program development, vocational evaluation, job placement and support services for the handicapped. Clary

ED 541A Practicum in Occupational Education. *Preq.: Grad. standing or PBS status. 1-6 F,S.* Under a faculty-supervised practicum in an educational, industrial or governmental setting, the student participates in and analyzes activities associated with the planning, implementation and evaluation of instructional programs or services in vocational education. A unique plan developed by the student and approved by the supervisor. Clary

ED 541B Practicum in Education Administration. *Preqs.: ED 550 and CI. 1-6 F,S.* Supervised experience in an appropriate educational setting to enable the student to gain practice in applying concepts, principles and theories of education administration. Graduate Staff

ED 542 Contemporary Approaches in the Teaching of Social Studies. *Preqs.: Advanced undergrad. or grad. standing. 3(3-0) S.* An analysis of the principles, strategies and application of new teaching approaches. Includes structured projects and practical experiences. Harper, Martorella

ED 543 Adulthood and Learning: The Later Years. *Preq.: ED 539 or CI. 3(3-0) S. Alt. yrs.* A study of basic sensory, attitudinal, intellectual and emotional changes that occur in individuals during the process of growing old and the implications of these changes for developing, implementing and evaluating educational programs for and with older adults. Glass

ED 544 The Teaching of Composition. *Preq.: 9 hrs. of ED, PSY and/or ENG. 3(3-0) S.* For classroom teachers. Offers practical field-tested ideas to help students improve as writers by focusing on composition as a process as well as a product. Activities for teaching prewriting, composing, revising, proofreading, grammar and evaluating practiced, with suggestions for individual group learning. Research related to effective composition teaching reviewed. Pritchard

ED 545 Reading in the Elementary School. *Preqs.: Six hrs. ED or PSY. 3(3-0) F. Alt. yrs.* Theoretical foundations of reading instruction and current methods and materials for teaching reading, with an emphasis on planning and implementing reading programs for children in kindergarten through grade six. Fox

ED 546 Reading in the Content Areas. *Preqs.: Six hrs. in ED or PSY. 3(3-0) S, Sum.* Methods in instruction for applying reading to content areas, with emphasis on means of improving comprehension, vocabulary and study skills in subject matter classrooms. Spires

ED 547 Language Arts in the Elementary School. *Preq.: Six hrs. in ED. 3(3-0) S. Alt. yrs.* Advanced professional training in the teaching of language arts for middle grades and elementary teachers, including an in-depth introduction to research-based teaching strategies, new instructional resources and the literature on the field. Fox

ED 548 Development of Microcomputer Software for Instruction. *Preq.: Six hrs. ED or PSY or CI. 3(3-1) F.* Course topics covered are the instructional design principles underlying the development of microcomputer-based instructional software and accompanying materials and programming principles and their implementation in courseware development. Additional topics include authoring languages, programming languages and graphics. Vasu

ED 549 Finance in Adult and Community College Education. *Preqs.: ED 500; grad. standing. 3(3-0) S.* Examination of theory, research, practices and issues in the development and management of financial resources of the adult and community college enterprise. Fountain, Tollefson

ED 550 Principles of Educational Administration. *Preqs.: Grad. standing, CI. 3(3-0) F, S.* This course designed as an introductory course in educational administration. Emphasizing basic principles of administration, the course draws upon administrative theory, business and public administration models as well as theoretical constructs from various disciplines. MacPhail-Wilcox

ED 551 Principles and Practices of Supervision. *Preqs.: 6 hrs. ED/PSY graduate study and CI. 3(3-0) S.* Designed to provide the educational leader with an understanding of the nature of instructional supervision, skills needed in supervising educational programs and an analysis of promising practices for improving programs. Opportunity provided for application of principles of supervision to one or more practical problems. Parramore

ED 553 Community Service Agencies. *Preq.: Six hrs. of ED, PSY or SOC or CI. 3(3-0). F.* An introduction to the issues, functions, and scope of the work being done in various human service agency programs; an overview of helping approaches with selected client populations; related professional concerns examined. Sprinthall

ED 554 Planning Programs in Agricultural Education. *Preq.: Grad. standing or PBS status. 3(3-0) F, S.* Consideration of the need for planning programs in education; objectives and evaluation of community programs; use of advisory group; organization and use of facilities. Graduate Staff

ED 555 Issues and Trends in Education for the Allied Health Professions. *Preq.: Grad. standing or CI. 3(3-0) Alt. yrs.* An analysis of educational and social factors influencing change in health professions education. Emphasis on problems of student selection and program articulation and the implications for health occupations education and health services of recent legislation regarding the handicapped. Patterson

ED 556 Learning Disabilities. *Preq.: ED 506 or CI. 3(3-0) F.* A study of the field of learning disabilities, including definitions, prevalence, etiology, characteristics and current educational trends for educating learning disabled students. Crossland

ED 557 Methods and Materials in Learning Disabilities. *Preq.: ED 556 or CI. 3(3-0) S.* A study of the current methods and materials for the teaching of learning disabled students in the elementary and/or secondary schools, including curriculum and instructional techniques. Course focuses on examination of commercial materials and the development of teacher-made materials for use with the learning disabled student. Crossland

ED 558 Resource Teaching in Special Education. *Preq.: ED 506 or CI. 3(3-0) F.* A study of resource teaching in the area of special education, with emphasis on resource teaching with the learning disabled and mentally retarded. Course focuses on types of resource programs, how to establish and maintain a program, selection of students, curriculum and materials. Graduate Staff

ED 559 The Adult Learner. *Preq.: Six hrs. in ED. 3(3-0) S.* Principles involved in adult education programs including theories and concepts undergirding and requisite to these programs. Emphasis given to interrelationship of the nature of adult learning, the nature of the subject matter and the setting in which learning occurs. The applicability of relevant principles and pertinent research findings to adult learning thoroughly treated. Graduate Staff

ED 560 Teaching through the Arts. *Preq.: 6 hrs. in ED and/or PSY. 3(3-0) F. Alt. yrs.* Examines the role of the arts in the teaching/learning process, emphasizing ways classroom teachers can use the arts to foster students' personal growth, creativity and academic achievement. Develops teaching skills through explorations in graphic arts, sculpture, dance/movement, drama, film, creative writing and poetry. Graduate Staff

ED 561 Educational Diagnosis and Prescription for Exceptional Children. *Preq.: ED 506 or CI. 3(3-0) S.* A study of the concept of educational diagnosis of exceptional students, including an examination of educational diagnostic procedures in current use in special education. Course focuses on the development of informal diagnostic techniques and procedures for adapting curriculum and instruction for the exceptional learner. Graduate Staff

ED 562 Communication Disorders in the Classroom. *Preq.: ED 506 or CI. 3(3-0) S. Alt. yrs.* A study of communication disorders which occur in the school age population, including types of disorders, prevalence, etiology, characteristics and corrective therapy. Course focuses on communication disorders among exceptional students and the classroom teacher's role in working with communication disorders. Crossland

ED 563 Effective Teaching. *Preq.: Twelve hrs. ED including student teaching. 3(3-0) F.* Analysis of the teaching-learning process; assumptions that underlie course approaches; identifying problems of importance; problem solution for effective learning; evaluation of teaching and learning; making specific plans for effective teaching. Graduate Staff

ED 564 Classroom Management in Special Education. *Preq.: ED 506 or CI. 3(3-0) S.* A study of the concepts and procedures involved in the design and implementation of techniques for managing exceptional students in a classroom setting. Course focuses on methods for increasing and maintaining appropriate classroom behaviors in exceptional learners. Graduate Staff

ED 565 Agricultural Occupations. *Preq.: 12 hrs. ED or CI. 3(3-0) F.S.* The theory of education and work is related to the expanding field of agricultural occupations. Career development in agricultural occupations associated with curriculum development needs. Occupational experience in agriculture seen in relation to the curriculum and the placement in agricultural occupations. Graduate Staff

ED 566 Occupational Experience in Agriculture. *Preq.: Grad. standing or PBS status. 3(3-0) F.S.* A major and critical element in all programs of vocational education is the provision for appropriate student learning experiences in a real and simulated employment environment. Due to recent developments in education and agriculture, new and expanded concepts of occupational experience have been devised. Current research substantiates the

need and desire of teachers of agriculture for assistance in implementing the new concepts. The course designed not only to provide this aid but to develop a depth of understanding of the theoretical foundations underlying the new developments in occupational experiences to stimulate individual growth and creativity in implementing further developments.

Graduate Staff

ED 567 Education of Special Adults Populations. *3(3-0) S, Sum.* Analyzing and developing adult education responses to the needs and characteristics of special adult populations such as nonliterate, unemployed, handicapped and older adults.

Fingeret

ED 568 Adult Education in Agriculture. *Preq.: Grad. standing or PBS status. 3(3-0) F, S.* Designed to meet the needs of leaders in adult education. Opportunity to study some of the basic problems and values in working with adult groups. Attention given to the problem of fitting the educational program for adults into the public school program and other educational programs as well as to the methods of teaching adults.

Flowers

ED 569 The Principalship. *Preq.: ED 550 or CI. 3(3-0) S. Alt. yrs.* A survey course covering the major responsibilities and tasks of a school principal, *e.g.*, curriculum and instructional leadership, teacher recruitment and selection, fiscal record keeping, pupil schedules, plant management. Students combine findings from their readings with present practices to develop workable solutions to managerial and instructional problems.

MacPhail-Wilcox

ED 570 Foundations of Mathematics Education. *Preq.: ED 471 or equivalent. 3(3-0) Sum.* A course on the current status of mathematics education with special emphasis on the study and critical analysis of current practices in mathematics instruction from elementary school through college.

Graduate Staff

ED 571 Introduction to the Gifted Individual. *Preq.: ED 506 or CI. 3(3-0) F.* A study of theories and concepts of giftedness and procedures in identifying the gifted, with a consideration of factors influencing giftedness and ways it may be fostered.

Aubrecht

ED 572 Methods for Teaching the Gifted. *Preq.: ED 571 or CI. 3(3-0) S.* A study of major approaches used in the education of the gifted, including an opportunity to develop a unit plan based upon one of these approaches.

Aubrecht

ED 573 Behavior Disorders. *Preq.: ED 506 or CI. 3(3-0) F.* A study of definitions, etiology, characteristics, philosophies and approaches to educational programming for children and youth with behavior disorders, including the emotionally handicapped, autistic and socially maladjusted.

Cullinan

ED 574 Methods and Materials: Behavior Disorders. *Preq.: ED 573 or CI. 3(3-0) S.* A study of curriculum materials, instructional strategies and behavior management techniques related to teaching behaviorally disordered children and youth, including individualized instruction, group process, organization and evaluation of classroom programs, parent involvement, community resources and teachers' personal and professional growth and development.

Cullinan

ED 575 Foundations of Science Education. *Preq.: ED 475 or equivalent. 3(3-0) S, Sum. Alt. yrs.* Study and analysis of the philosophical, historical, sociological, political and economic factors affecting science education in the schools of the United States. Implications for science education of various learning theories examined along with models for curriculum development and program planning. Critical analysis of current trends, issues and problems in science education in terms of multiple perspectives. Anderson, Wheatley

ED 576 Teaching/Learning Approaches for Emerging Adolescents. *Preqs.: ED 507 or equivalent; grad standing and CI. 3(3-0) S.* Exploration of teaching/learning approaches appropriate to emerging adolescents. Topics include learning styles; interdisciplinary inquiry; community-based curriculum; simulations and games; learning centers; mini-courses; design of physical space; all-school activities.

Arnold

ED 577 Improving Classroom Instruction in Science. *Preq.: ED 475 or equivalent. 3(3-0) S.* Application of major principles of education and psychology to the improvement of science teaching in elementary, middle and secondary schools. Emphasis on critical analysis of research and the development of research-based classroom applications. Topics include goals and objectives of science teaching, instructional strategies, development or selection of science materials, evaluation of achievement and elements of a desirable classroom climate. Graduate Staff

ED 578 Law and Higher Education. *Preq.: Six hrs. grad. credit. 3(3-0) S. Alt. yrs.* A study of constitutional, statutory and case law as it relates to higher education. Emphasis on faculty, student and staff rights and tort liability. Beezer

ED 579 Concepts and Principles of Evaluation Applied to Non-formal Adult Education Programs. *Preq.: ED 503 or CI. 3(3-0) S.* Introduction to the evaluation of non-formal adult educational programs; course topics include the purposes of evaluation, alternative concepts and techniques, stake holders and their concerns, the specification of evidence, selection of standards for making judgments, gathering and analysis of data, use and dissemination of results and handling problems in evaluation. Graduate Staff

ED 580 Evaluation Theory and Practice in Education. *Preq.: ED 532 or equivalent. 3(3-0) F.* A review of educational program evaluation with emphasis on (1) theory and conceptual models of evaluation, (2) evaluation design, and (3) environmental practical factors influencing the design and implementation of evaluation studies. Graduate Staff

ED 581 Curriculum and Instruction in the Allied Health Professions. *Preqs.: Advanced undergrad. or grad. standing and CI. 3(3-0) Alt. yrs.* A study of the elements of curriculum design and theoretical considerations for the development of curricula in the health occupations. Identification, analysis and evaluation of instructional strategies appropriate for clinical and classroom teaching. Patterson

ED 582 Teaching Braille and Communication Skills. *Preqs.: ED 513 and ED 545 or equivalent. 3(3-0) S.* Information-access methods for visually impaired learners. Methods and materials for teaching Braille reading and selecting and teaching the use of electronic aids. Graduate Staff

ED 583 Design and Evaluation of Instructional Materials. *Preq.: Grad. standing. 3(3-0) S.* Emphasis upon the characteristics and selection of various media for instruction and their use in educational settings. Instructional materials designed and produced. Analysis of the research in the field conducted. Projects and assignments individualized. Application of grounded research and theory concerning learning to the design of instructional materials. Structured projects and practical experiences used to transfer design principles and evaluate instructional products. Martorella

ED 584 Health Care Delivery Systems and Environments. *Preqs.: Grad. standing and CI. 3(3-0) Alt. yrs.* Organization of the health care delivery system, services and resources. Focus on the major social, economic, political and professional factors which contribute to shaping the system and influence change. Organizations and environments analyzed in regard to the demand for health manpower and the implications for health occupations education. Patterson

ED 585 Qualitative Research in Adult and Community College Education. *Preq.: Grad. standing. 3(3-0) F.* Designing qualitative studies, conducting field work including open-ended interviews and participant observation, analyzing data and understanding theoretical and philosophical background of this research approach. Fingeret

ED 586 Methods and Materials in Visual Impairments. *Preqs.: ED 506, ED 513. 3(3-0) S.* A study of current methods and materials for teaching visually impaired learners. Includes curriculum and materials development, adaptation, instructional techniques, educational assessment and diagnosis. Graduate Staff

ED 587 Organization and Operation of Training and Development Programs. *3(3-0) F.* Overview of occupational education as is practiced in business and industrial settings. Roles common to training and development specialists are presented, including managerial concerns related to organizing, operating and financial training and development programs. Dillon

ED 588 Advanced Teaching Methods in Industrial Arts Education. *Preq.: ED 362 or equivalent. 3(2-2) F, Sum.* An intensive examination of the teaching-learning process applicable to laboratory-classroom instruction. Instructional technology, evaluation, classroom control and management given attention. Wenig, Graduate Staff

ED 589 Personnel Appraisal in Education. *Preqs.: PSY 532 and PSY 535. 3(3-0) S. Alt. yrs.* Examination of issues, models, theories and research pertaining to personnel appraisal in education. Graduate Staff

ED 590 Special Problems in Guidance. *Preqs.: Six hrs. grad. work in department or equivalent and CI. Maximum 6 F, S.* Intended for individual or group studies of one or more of the major problems in guidance and personnel work. Problems selected to meet the interests of individuals. The workshop procedure used whereby special projects, reports and research developed by individuals and by groups. Graduate Staff

ED 591 Teaching Literature for Young Adults. *Preq.: Sr. or grad. standing or PBS status. 3(3-0) S. Alt. yrs.* Designed to acquaint in-service and pre-service teachers with the breadth and diversity of contemporary literature for adolescents, with an emphasis on teaching young adult literature. Addresses the history and themes of young adult literature, readability of materials, reading preferences, literary merit, skills that can be taught through literature, censorship, motivating students to read and organizing literature units. Pritchard

ED 592 Special Problems in Mathematics Teaching. *Preq.: ED 471 or equivalent. 1-3 F, S, Sum.* An in-depth investigation of topical problems in mathematics teaching chosen from the areas of curriculum, methodology, technology, supervision and research. Graduate Staff

ED 593 Special Problems in Occupational Education. *Preq.: Sr. standing, PBS status or grad. standing in OED. 1-6 F, S, Sum.* Guided independent or group study of current problems or topics in occupational education. Graduate Staff

ED 594 Special Problems in Science Teaching. *Preq.: ED 476 or equivalent. 1-6 Sum.* An in-depth investigation of topics in science education not covered in existing courses. Includes critical analysis of research and may include field work. May be offered on individual basis or as a class. Anderson, Wheatley

ED 595 Methods and Techniques of Training and Development. *3(3-0) S.* Methods and techniques common to model occupational education programs in business and industrial settings discussed. Course focuses on how to design and evaluate effective learning programs and instructional methodologies. Dillon

ED 596 Topical Problems in Adult and Community College Education. *Preq.: Grad. standing or PBS status. Credits arranged. F, S, Sum.* Study and scientific analysis of problems in adult education and preparation of a scholarly research type of paper. Graduate Staff

ED 597 Special Problems in Education. *Preq.: Grad. standing or PBS status. 1-3 F, S, Sum.* Designed to provide graduate students in education opportunity to study problem areas in professional education under the direction of a member of the graduate faculty. Graduate Staff

ED 598 Special Problems in Curriculum and Instruction. *Preqs.: Six hrs. of ED or PSY and CI. 1-6 F,S,Sum.* Designed to provide an in-depth study of topical problems in curriculum and instruction selected from the areas of current concern to practitioners in education. Graduate Staff

ED 599 Research Projects in Education. *Preqs.: CI; ED 532 or equivalent. 1-3 F,S,Sum.* A project or problem in research in education for graduate students, supervised by members of the graduate faculty. The research chosen on the basis of individual students' interests and not to be part of thesis or dissertation research. Graduate Staff

FOR GRADUATES ONLY

ED 600 Organizational Concepts and Theories Applied to Adult and Community College Education. *Preqs.: ED 503, PS 502, SOC 541. 3(3-0) F.* This course designed for present and potential administrators interested in increasing their understanding of organization as a basis for administering effective adult and community college education programs. Shearon

ED 601 Administrative Concepts and Theories Applied to Adult and Community College Education. *Preq.: ED 600 or a comparable course(s) on organizational theory. 3(3-0) S.* Designed for persons interested in building a more consistent philosophy of educational administration, extending and strengthening their understanding of administrative concepts and processes, improving their comprehension of the theoretical and research foundations upon which administrative processes are predicated, and increasing their ability to apply administrative concepts, theories and principles to the management of the complex education system. Graduate Staff

ED 602 Curriculum Theory and Development. *Preqs.: 9 semester hrs. graduate PSY, ED 502, ED 514 or CI. 3(3-0) F.* A study of theory and research in the behavioral sciences and education designed to provide the theoretical background for the development of elementary and secondary curricula. The knowledge base and skills for critical review of curricula and instructional materials explored and an opportunity to apply these provided. Arnold, Parramore

ED 603 Teaching Mathematics and Science in Higher Education. *Preqs.: ED 570, 592 or 594, grad. standing, CI. 3(3-0) S.* Collegiate mathematics and science instruction examined with respect to goals and objectives, design of courses and curricula, innovative programs and facilities, and methods and materials for instruction. Graduate Staff

ED 604 Curriculum Development and Evaluation in Science and Mathematics. *Preqs.: 500-level statistics, ED 615 or PSY 535, CI. 3(3-0) S.* A critical study of the elements of curriculum design and theory in mathematics education and science education and the examination of evaluation procedures for assessing educational innovations. Graduate Staff

ED 605 Education and Supervision of Teachers of Mathematics and Science. *Preqs.: ED 470 or 475 or equivalent, ED 570 or 592 or 594. 3(3-0) S.* Critical analysis of theories, programs and techniques designed to promote interpersonal interactions that will lead to more effective teaching of science and mathematics. Graduate Staff

ED 606 Remediation of Reading Disabilities. *Preq.: ED 547 or CI. 3(3-0) S. Alt. yrs.* Advanced approaches to reading remediation examined including theory and research related to remedial instructional strategies, analyses of instructional designs and evaluations of the effectiveness of intervention programs. Fox

ED 607 The Politics of Higher Education. *Preqs.: Grad. standing or Management Development Certificate Program and six semester hours of 500-level course work. 3(3-0).* An examination of the differing and changing perceptions of the role of higher education in American society; the politics of competition for priority of attention and resources; organizational alternatives in its control; relevant elements in the structure and processes of government. References to other societies. Graduate Staff

ED 609 Planning and Organizing Industrial and Technical Education Programs. *Preqs.: ED 516 and grad. standing. 3(3-0) F.* In this course a study made of the influences which impinge upon the development of programs of occupational education. Adequate opportunity also provided to examine in detail steps that may be taken to analyze needs for occupational education, to organize for its provision, to study its offerings and to evaluate its results.
Graduate Staff

ED 611 Laws, Regulations and Policies Affecting Occupational Education. *Preq.: ED 527 or ED 630. 3(3-0) S.* A detailed study of legislation (national and state) which applies directly to occupational education. Basic social issues and economic conditions which precipitated the legislation studied in depth. A review also made of the organizational structure and policies under which national legislation converted into programs of occupational education.
Farmer

ED 612 Finance, Accounting and Management of Occupational Education Programs. *Preq.: ED 610. 3(3-0) S. Alt. yrs.* A study of the steps which must be taken in financing a new occupational enterprise, following the determination of curriculum by area study. All financial transactions such as costs of operation, equipment purchase procedures and costs for construction investigated in detail.
Belcher

ED 614 Contemporary Educational Thought. *Preqs.: Twelve hrs. ED; CI. 3(3-0) S. Alt. yrs.* This course based on a reading and discussion of twentieth-century works in educational philosophy. Such movements as pragmatism, reconstruction, perennialism and existentialism considered.
Graduate Staff

ED 616 History of Higher Education in the United States. *Preqs.: Six hrs. of grad. ED courses and CI. 3(3-0) S. Alt. yrs.* A study of the history of higher education from the colonial period to the present. Emphasis on how philosophic, political, social and economic forces influence the function and structure of higher education.
Harvey

ED 618 School Law for the Administrator. *Preq.: ED 518 or equivalent. 3(3-0) S. Alt. yrs.* A comprehensive study of constitutional, statutory and case law as it relates to elementary and secondary school administration. Emphasis on legal issues associated with governance, finance, property, personnel and curriculum.
Beezer

ED 620 Cases in Educational Administration. *Preqs.: Grad. standing and CI. 3(3-0) S. Alt. yrs.* This course utilizes the case study and case simulation approach to the study of school administration. Administrative concepts developed and applied to simulated situations and to actual case histories. The administrative process viewed as a decision-making process. The student expected to make decisions after considering alternative courses of action and after projecting probable consequences.
Dolce

ED 621 Internship in Education. *Preqs.: Nine hrs. in grad. level courses and CI. 3-9 F,S,Sum.* Utilizing the participant-observer role, this course requires participation in selected educational situations with emphasis upon development of observational skills, ability to record relevant observations by means of written journals, skills in analyzing experiences identifying critical incidents and projection of events and consequences. The student required to develop possible alternative courses of action in various situations, select one of the alternatives and evaluate the consequences of the course of action selected.
Graduate Staff

ED 625 Cross Cultural Counseling. *Preqs.: ED 530; 9 semester hrs. grad.-level ED. 3(3-0) S.* Theory and practice of counseling culturally different clients. Client populations include African-Americans, Asian-Americans, American Indians and Hispanics. Topics include cultural assumptions, cultural values, counselor credibility, prejudice and racism in the context of counseling.
Locke

ED 630 Philosophy of Industrial Arts Education. *Preq.: Twelve hrs. in ED. 3(3-0) S. Alt. yrs.* Origins, development of industrial arts education. Philosophical foundations, derivation of objectives and criteria for evaluation. Contributions of the heritage to contemporary concepts of industrial arts education.
Wenig

ED 631 Vocational Development Theory. *Preq.: Grad. standing or PBS status. 3(3-0) F. Alt. yrs.* A study of the major theories and constructs of vocational development with implications for counseling and career planning. Jones

ED 632 Applied Research Methods in Education. *Preqs.: ST 507 and ED 532 or equivalent; Coreq.: ST 508 or CI. 3(1-4) S.* Through the use of simulated educational settings consideration given to the development of research proposals or plans, selection and/or development of appropriate measurement instruments and the purposes and functions of various statistical designs and procedures. Simulated data prepared and analyzed using computer-based statistical packages, the results interpreted and a research report produced. Graduate Staff

ED 634 Diagnosis of Reading Disabilities. *Preq.: ED 545 or ED 546, 3(3-0) F. Alt. yrs.* Formal and informal instruments for diagnosing reading disabilities including the completion of a diagnostic case study describing the reading performance of a disabled reader. Fox

ED 635 Administration and Supervision of Industrial Arts. *Preq.: Twelve hrs. in ED. 2(2-0) F, S.* Study of the problems and techniques of administration and supervision of industrial arts in schools and universities. Selection of teachers, teacher improvement methods, public relations, facilities planning and specification. Graduate Staff

ED 636 Observation and Supervised Field Work. *Preq.: CI. Max. 3 F, S.* Provides opportunity for observation and practice of guidance and personnel services in schools, institutions of higher education, agencies, business and industry. Graduate Staff

ED 637 Seminar in Cognitive-Developmental Theory and Practice. *Preqs.: Advanced grad. standing and CI. 3(3-0) F. Alt. yrs.* Analysis of major contemporary theories of cognitive development (Erikson, Kohlberg, Loevinger, Hunt, Perry) as a basis for deliberate counseling and curricular interventions. Sprinthall

ED 638 Seminar in Cognitive-Development Research. *Preqs.: Grad. standing; ED 637; CI. 3(3-0) S. Alt. yrs.* A review of current systems of cognitive-developmental assessment; methods for measuring psychological growth included. Specific research design models reviewed as a basis for action-research. Sprinthall

ED 639 Group Counseling. *Preqs.: ED 530 and one of the following: ED 520, 534, 535 or 553. 3(3-0) F, Sum.* Theory and practice of group counseling. Theoretical positions include client-centered, behavioral and rational-emotive. Aspects of group process include group leadership, group membership, establishing a group and maintaining a group. Graduate Staff

ED 640 Laboratory Experiences in Counseling. *Preqs.: ED 520 or equivalent; PSY 535; Coreq.: ED 530. 3(3-0) F.* The identification and practice of fundamental skills needed for a person to function as an effective counselor. Emphasized is development of specific skills in: counseling, testing, human relations, identification of client problems and the design of counseling strategies. Graduate Staff

ED 641A Practicum in Counseling. *Preqs.: Advanced grad. standing, CI. 2-6 S.* A practicum course in which the student participates in actual counseling experience under supervision in a school, college or agency setting. Graduate Staff

ED 641B Diagnostic-Prescriptive Practicum in Reading. *Preqs.: ED 545 or ED 546 and ED 547 and CI. 3(3-0) S.* Supervised teaching experience where students use diagnostic test data to prescribe remedial programs for reading-disabled individuals, implement instructional prescriptions and evaluate the success of remedial plans. Graduate Staff

ED 641C Practicum in Special Education. *Preq.: CI. 1-6 F, S.* Practicum designed to meet the individual needs of the students enrolled in the course. The practicum may involve

diagnosis of exceptional students, writing educational prescriptive plans for exceptional students, or it may focus on an individual topic that involves working directly with exceptional learners. Graduate Staff

ED 641D Practicum in Science and Mathematics Education. *Preq.: ED 570 or ED 575. 1-6 F,S.* Supervised practicum in appropriate settings both on- and off-campus. Provides an opportunity for development, implementation and evaluation in science and mathematics in a clinical environment under faculty supervision. Graduate Staff

ED 641G Practicum in Middle Years Education. *Preqs.: ED 507 or equivalent; grad. standing and CI. 3-6 F,S.* Designed to provide practical experience in schools and area agencies concerned with middle and junior high school education. Arnold

ED 641J Practicum in Health Occupations. *Preqs.: 21 hrs. grad. work including ED 581 and CI. 3(3-0) Alt. yrs.* Based upon the participants' professional objectives, a practicum in a teaching or an administrative context designed appropriate to the individual's particular discipline and area of function. Program designed by the student in cooperation with the preceptor and course instructor. Patterson

ED 641K Practicum in Supervision. *Preq.: ED 551 or equivalent. 3-6 F,S.* Practical experience in schools, school systems and area educational agencies concerned with instructional supervision. Parramore

ED 641M Practicum in Instructional Technology—Computers. *Preq.: 12 hrs. in instructional technology—computers. 3-6 F,S.* Designed to provide practical experience in schools and area agencies concerned with integrating the computer into the curriculum. Martorella, Vasu

ED 642 Research Applications in Curriculum and Instruction. *Preq.: ST 507 or equivalent. 3(3-0) S.* Focus on selected methodological issues and research findings in the areas of curriculum development and supervision, instructional technology, English education, language arts, middle grades education, reading education, social studies and special education. Vasu

ED 643 The American College Student. *Preq.: ED 535 or doctoral standing. 3(3-0) S. Alt. yrs.* An advanced-level course designed for investigation of the five main families of theories of college student development as presented by Chickering, Perry, R. Heath, Myers-Briggs, Holland and D. Heath. Assessment and research in student development considered, and students design and implement a developmental intervention based on Knefelkamp and Wells' Practice-to-Theory-to-Practice model. Graduate Staff

ED 648 Theory and Process in Reading and Language Arts. *Preqs.: ED 545 and CI. 3(3-0) S. Alt. yrs.* Advanced study of theoretical models of reading, research issues in reading and in other language processes. Theoretical models of reading studied in depth. Emphasis placed on critical examination and analysis of research investigating reading acquisition, mature reading behavior and related language processes. Fox

ED 660 Industrial Arts Curriculum. *Preq.: IA 645. 3(3-0) F,S,Sum.* Industrial arts curriculum origins, analysis, organization, evaluation, revision. Subject matter deviation and classification applicable to all levels of instruction. Relationships among curriculum, philosophy and methodology. (Also see ED 608, ED 610, ED 630, ED 635 and ED 692.) Graduate Staff

ED 664 Supervision in Agricultural Education. *Preq.: ED 554. 3(3-0) F,S.* Organization, administration, evaluation and possible improvement of supervisory practice; theory, principles and techniques of effective supervision in agricultural education at different levels. Graduate Staff

ED 665 Supervising Student Teaching. *Preq.: Twelve hrs. of ED. 3(3-0) F,S.* A study of the program of student teaching in teacher education. Special consideration given the role

of the supervising teacher, including the following areas: planning for effective student teaching, observation and orientation, school community study, analysis of situation, evaluating student teachers and coordination with NCSU. Graduate Staff

ED 666 Supervision of Counseling. *Preq.: CI. 3(1-8) F.S.* A supervised practicum for doctoral students in assisting with the supervision of first-year students in laboratory and practicum experiences in individual or group counseling. Graduate Staff

ED 686 Professional Issues in Counseling. *Preq.: Doctoral standing. 1-3 F.S. Alt. yrs.* Consideration of contemporary issues, trends and recent research in the field of counseling. Locke

ED 687 Seminar in Curriculum and Instruction. *Preq.: Doctoral standing. 1-3 S.* Consideration of contemporary issues, trends and recent research and development findings in curriculum and instruction. Graduate Staff

ED 688 Research Application in Occupational Education. *Preq.: ED 532. 3(3-0) F.S.* This course concerned with methodology, application, analysis and synthesis of research in occupational education. A review of current occupational education studies, clustered by areas, made with attention to statistical techniques, data collecting, data handling, and the audience and impact of particular projects and research organizations. The class activities in research application designed to bridge the gap between the theories of research methodology and the student's independent research projects. Coster, Graduate Staff

ED 690 Seminar in Mathematics Education. *Preq.: Departmental major or CI. 2(2-0) F.S.* An in-depth examination and analysis of the literature and research in a particular topic(s) in mathematics education. Graduate Staff

ED 692 Seminar in Industrial Arts Education. *Preq.: Grad. standing. 1(1-0) F.S.* Reviews and reports on special topics of interest to students in industrial arts education. Graduate Staff

ED 693 Advanced Special Problems in Occupational Education. *Preq.: Master's degree in vocational field or CI. 1-6 F.S., Sum.* Guided independent or group study of advanced problems, issues or developments in planning, organizing, teaching, administering and/or evaluating occupational education programs. Graduate Staff

ED 695 Seminar in Science Education. *Preq.: Department major or CI. 2(2-0) F.S.* An in-depth examination and analysis of the literature and research in a particular topic(s) in science education. Graduate Staff

ED 696 Seminar in Adult and Community College Education. *Preq.: Grad. standing. 1-3 F.S.* Identification and scientific analysis of major issues and problems relevant to adult education. Credit for this course involves the active participation of the student in a formal seminar and scientific appraisal and solution of a selected problem. The course designed to help the student acquire a broad perspective of issues confronting adult educators and to acquire experiences in the scientific analysis and solution of specific issues. Graduate Staff

ED 697 Problems of Research Design in Education. *Preqs.: ED 632 and CI. 1-3 S. Alt. yrs.* Provides the student with an individualized but structured investigation of alternative problem definitions, research methodologies and statistical analyses for a problem of his/her choosing, usually associated with thesis or dissertation. In small groups or individually with the instructor, the student considers research design, measurements and statistical analysis necessary to conduct research. Graduate Staff

ED 698 Seminar in Occupational Education. *Preq.: ED 527 or ED 630. 3(3-0) F.S.* This course designed as a seminar-type course, with topics selected each semester. Attention given to the broad concepts of occupational education as manifested in the Vocational Education Act of 1963 and its amendments, and to the problems and issues underlying the

development of and implementation of programs of occupational education at elementary, junior high, senior high and postsecondary levels. Coster, Graduate Staff

ED 699 Thesis and Dissertation Research. *Preqs.: 15 hrs. of ED; CI. Credits Arranged. F,S,Sum.* Individual research on a thesis or dissertation problem. Graduate Staff

Electrical and Computer Engineering

GRADUATE FACULTY

Professor R. K. Cavin III, Head

Associate Professor W. T. Easter, Associate Head

Professor W. E. Alexander, Graduate Administrator

Professors: D. P. Agrawal, B. J. Baliga, S. M. Bedair, W. Chou, R. E. Funderlic, T. H. Glisson Jr., J. J. Grainger, J. R. Hauser, J. F. Kauffman, S. K. Khorram, M. A. Littlejohn, N. A. Masnari, N. F. J. Matthews, L. K. Monteith, H. T. Nagel Jr., A. A. Nilsson, J. B. O'Neal Jr., C. M. Osborn, A. Reisman, D. R. Rhodes, R. J. Trew, H. J. Trussell, A. Vanderlugt, J. J. Wortman; *Adjunct Professors:* E. Christian, W. A. Flood; *Visiting Professors:* H. W. Etzel, J. R. Suttle; *Professors Emeriti:* W. J. Barclay, A. R. Eckels, A. J. Goetze, G. B. Hoadley; *Associate Professors:* S. T. Alexander, G. F. Bland, R. M. Kolbas, R.-C. Luo, T. K. Miller III, U. K. Mishra, S. A. Rajala, W. E. Snyder, M. W. White; *Adjunct Associate Professors:* F. Brglez, J. R. Burke, S. H. Lee, J. R. Jones, S. E. Kerns; *Associate Professors Emeriti:* N. R. Bell, E. G. Manning, W. C. Peterson; *Assistant Professors:* S. H. Ardalan, R. S. Colby, E. F. Gehringer, R. S. Gyurcsik, A. W. Kelley, W.-t. Liu, D. L. Lubkeman, J. J. Paulos, D. S. Reeves, G. A. Ruggles, M. B. Steer, J. K. Townsend; *Visiting Assistant Professors:* M.-Y. Chow, M. E. Elbuluk, K. W. Kim, M. C. Ozturk, D. E. Van den Bout, I. Viniotis; *Lecturer:* J. C. Sutton III; *Visiting Lecturer:* G. F. Abbott

INTERINSTITUTIONAL ADJUNCT GRADUATE FACULTY

S.-s. Chen, K. Daneshvar, J. H. Kim, R. Makki, H. L. Martin Sr., E. H. Nicollian

The Department of Electrical and Computer Engineering offers programs leading to the Master of Science (M.S.) and the Doctor of Philosophy (Ph.D.). A thesis is optional in the M.S. program. In both electrical engineering and computer engineering, the department offers a non-thesis option in telecommunications. A student pursuing the option must satisfy all requirements for a non-thesis M.S. degree but with additional restrictions on courses selected in fulfillment of the requirements.

Admission to the graduate program requires a previous degree in electrical engineering, computer engineering or a related engineering or scientific discipline. Students holding degrees in other than electrical or computer engineering may be required to do additional work. All students admitted to the M.S. program are admitted initially to the non-thesis program. Permission to pursue the M.S. with thesis is granted when the student identifies a suitable subject for research and a member of the ECE graduate faculty agrees to direct the

research. Applicants who are not citizens of the United States must submit scores on the general portion of the Graduate Record Examination (GRE). Applicants seeking fellowships are strongly encouraged to submit scores on the general portion of the GRE.

Areas of concentration in electrical engineering include circuits, electromagnetics and microwave systems, signal processing, image processing, robotics and computer vision, solid-state materials and devices, optical signal processing, communications, power electronics, and power systems. Areas of concentration in computer engineering include computer communications, computer performance modeling, computer architecture, VLSI design, digital systems, and software engineering. Much of the research in these areas is pursued under the auspices of the Center for Communication and Signal Processing, the Computer Systems Laboratory, the Electric Power Research Center, the Solid-State Laboratories and the Center for Advanced Electronic Materials Processing. In addition, many graduate students in the department benefit from association with the Microelectronics Center of North Carolina and with other industrial companies in the nearby Research Triangle Park.

Although the Department of Electrical and Computer Engineering and the Department of Computer Science administer separate graduate programs, they do so under a single, jointly held graduate computer engineering degree authorization. As a result, the departments cooperate closely in graduate education and research by sharing responsibility for a number of graduate courses, jointly operating the Computer Systems Laboratory, collaborating in research and administering a number of joint faculty appointments. The close cooperation of the departments offers graduate students in both disciplines an unusually wide range of educational and research opportunities.

The department, the College of Engineering, the Graduate School and several industrial companies offer various kinds of financial assistance to qualified students, including fellowships and teaching and research assistantships. In addition, most students who are citizens or permanent residents of the United States receive tuition scholarships equal to the difference between resident and nonresident tuition.

Additional information will be provided to interested and qualified applicants. Requests for information should be directed to: Graduate Coordinator, Department of Electrical and Computer Engineering, NCSU, Box 7911, Raleigh, NC 27695-7911.

SELECTED ADVANCED UNDERGRADUATE COURSES

ECE 401 Introduction to Signal Processing. *Preqs.: ECE 301, ECE 302. 3(3-0) F,S.*

ECE 409 Introduction to Telecommunications Engineering. *Preq.: ECE 301. 3(3-0) F.*

ECE 431 Electronics Engineering. *Preq.: ECE 314. 3(2-3) F,S.*

ECE 432 Communications Engineering. *Preqs.: ECE 301, ECE 314. 3(2-3) S.*

ECE 435 Elements of Control. *Preqs.: ECE 305, ECE 314. 3(2-3) F.*

ECE 436 Digital Control Systems. *Preq.: ECE 435. 3(3-0) S.*

- ECE 439 Integrated Circuit Technology and Fabrication.** *Preq.: ECE 441. 3(2-2) S.*
- ECE (CSC) 440 Digital Systems Interfacing.** *Preq.: CSC 312 or ECE 340. 3(2-2) S.*
- ECE 441 Introduction to Solid-State Devices.** *Preqs.: ECE 303, ECE 314. 3(3-0) F.*
- ECE 444 Computer Control of Robots.** *Preqs.: ECE 314; and ECE 340 or ECE 212. 3(2-3) F,S.*
- ECE 446 VLSI Systems Design.** *Preqs.: ECE 314 and ECE 340 or ECE 212. 4(3-2) F,S.*
- ECE 448 Microwave Antennas, Radars and Communication Systems.** *Preq.: ECE 303. 3(3-0) F.*
- ECE 451 Power System Analysis.** *Preq.: ECE 305. 3(3-0) F.*
- ECE 452 Power Systems Protection.** *Preq.: ECE 451. 3(3-0) S.*
- ECE 454 Electrical Machinery.** *Preq.: ECE 305. 3(3-0) S.*
- ECE 455 Computer Control of SCR Motor Drives.** *Preq.: ECE 305 or ECE 331. 3(1-4) F,S.*
- ECE 457 Semiconductor Power Conversion.** *Preq.: ECE 314. 3(3-0) F.*
- ECE 492 Special Topics in Electrical and Computer Engineering.** *Preq.: CI. 1-4 F,S.*

FOR GRADUATES AND ADVANCED UNDERGRADUATES

- ECE (CSC) 501 Operating Systems Principles.** *3(3-0) F. (See computer science.)*
- ECE (CSC) 506 Digital Systems Architecture.** *3(3-0) F. (See computer science.)*
- ECE (CSC) 510 Software Engineering.** *3(3-0) F. (See computer science.)*
- ECE 511 Analog Electronics.** *Preqs.: ECE 431, grad. standing or B average in ECE and MA. 3(2-3) S.* A study of analog integrated circuits and analog integrated circuit design techniques. Review of basic device and technology issues. Comprehensive coverage of MOS and Bipolar operational amplifiers. Brief coverage of analog-to-digital conversion techniques and switched-capacitor filters. Strong emphasis on the use of computer modeling and simulation as a design tool. Students required to complete an independent design project.
Paulos
- ECE (CSC) 512 Compiler Construction.** *3(3-0) S. (See computer science.)*
- ECE (CSC) 513 Digital Signal Processing.** *Preqs.: ECE 401, B average in ECE and MA or CI. 3(3-0) F.* Digital processing of analog signals. Offline and real-time processing for parameter, waveshape and spectrum estimation. Digital filtering and applications in speech, sonar, radar, data processing, and two-dimensional filtering and image processing.
W. Alexander, Rajala, Trussell
- ECE (CSC) 514 Random Processes.** *Preqs.: ECE 301, B average in ECE and MA. 3(3-0) F.* Probabilistic descriptions of signals and noise, including joint, marginal and conditional densities, autocorrelation, cross-correlation and power spectral density. Linear and nonlinear transformations. Linear least-squares estimation. Signal detection.
T. Alexander, O'Neal
- ECE 515 Telecommunications Transmission Systems.** *Preq.: Grad. standing. 3(3-0) S.* Analysis of the components of a large telecommunications system with direct dialing. A detailed study of high-capacity digital (baseband, carrier and optical) and analog (carrier)

systems. Includes multiplexers, protection switching, diversity, microwave antennas and propagation, and noise in digital and analog systems. Hutchison, O'Neal

ECE 516 System Control Engineering. *Preq.: ECE 435 or ECE 301. 3(3-0) F.* Introduction to analysis and design of continuous and discrete-time dynamical control systems. Emphasis on linear, single-input, single-output systems using state variable and transfer function methods. Topics include open and closed-loop representation; analog and digital simulation; time and frequency response; stability by Routh-Hurwitz, Nyquist and Liapunov methods; performance specifications; cascade and state variable compensation. Assignments utilize computer-aided analysis and design programs. Chow

ECE (CSC) 518 Computer Graphics. *3(3-0).* (See computer science.)

ECE (CSC) 520 Fundamentals of Logic Systems. *Preqs.: ECE 318, B average in ECE and MA. 3(3-0) F.* A study of algebraic structures as related to logic systems, models for switching circuit behavior and their relation to hardware implementation. Includes theoretical treatment of both combinational and sequential logic systems concepts. W. Alexander

ECE (CSC) 521 Digital Computer Technology and Design. *Preq.: ECE 342. 3(3-0) F.S.* A study of the internal structure and organization of digital systems with the computer as a primary focus. The emphasis is on problem description and modeling as required in the design process. The design of all major components in digital systems, including memory, input-output and control utilizing current technology, discussed. Miller

ECE 525 Optical Signal Processing. *Preq.: ECE 301. 3(3-0) F.* Review of key principles from geometric optics; resolving power and the optical invariant and their relation to principles of communication theory; Fresnel and Fourier transformations and a study of direct and heterodyne detection, photodetectors, dynamic range, spatial filtering and carrier-frequency methods; applications such as spectrum analysis, pattern recognition and signal detection. Graduate Staff

ECE 530 Physical Electronics. *Preqs.: ECE 303, B average in ECE and MA. 3(3-0) S.* A study of the properties of charged particles under the influence of fields and in solid materials. Quantum mechanics, particle statistics, semi-conductor properties, fundamental particle transport properties, p-n junctions. Ruggles

ECE 531 Principles of Transistor Devices. *Preq.: ECE 441. 3(3-0) S.* An analysis of the operating principles of transistor structures. Basic semiconductor physics reviewed and used to provide an explanation of transistor characteristics. Device-equivalent circuits developed and used to interpret semiconductor-imposed limitations on device performance. Devices analyzed include MESFET'S, HEMT'S, Bipolar transistors, PBT'S, heterojunction BJTs and SIT's Trew

ECE 532 Principles of Microwave Circuits. *Preq.: Grad. standing or B average in ECE and MA. 3(3-0) F.* Principles required to understand the behavior of electronic circuits operating at microwave frequencies. This course starts with a review of electromagnetic theory and establishes an understanding of the techniques required for working with electronic circuits at microwave and millimeter-wave frequencies. Circuit components that operate at these frequencies discussed. Trew

ECE (CSC) 533 Digital Electronics. *Preqs.: ECE 314, grad. standing or B average in ECE and MA. 3(3-0) S.* A study of digital integrated circuits and digital integrated circuit design techniques. The following topics covered: semiconductor, device and technology issues; bipolar logic circuits including TTL, ECL and IIL; static and dynamic MOS logic circuits; and semiconductor memory circuits. A strong emphasis placed on the use of computer modeling and simulation as a design tool. The completion of three design projects required. Gyurcsik

ECE 537 Microwave Device Characterization Techniques. *Preq.: ECE 448. 3(1-5) F.* A laboratory in principles of microwave characterization and operation of microwave test equipment such as spectrum analyzers, power meters, detectors and network analyzers. Measurements of impedance noise figure, equivalent circuit parameters and frequency response will be performed on various circuit elements and devices. Graduate Staff

ECE 539 Integrated Circuit Technology and Fabrication. *Preq.: ECE 441. 3(2-2) S.* A study of semiconductor device and integrated circuit processing and technology. Covers sample preparation and specification, oxidation, diffusion, ion implantation, photolithography, design rules and measurement techniques. Osburn, Wortman

ECE 540 Electromagnetic Fields. *Preq.: ECE 448. 3(3-0) S.* A brief review of Maxwell's Equations, constitutive relations and boundary conditions. Power and energy relations for plane waves in isotropic and anisotropic media. Analysis of transmission lines, hollow metallic wave guides and dielectric waveguides. Green functions and applications to radiation and scattering. Electromagnetics and special relativity. Kauffman

ECE (CSC) 542 Database Management. *3(3-0) F.* (See computer science.)

ECE 546 VLSI Systems Design. *Preq.: ECE 342. 3(3-0) F.* Digital systems design in CMOS VLSI technology: CMOS device physics, fabrication, primitive components, design and layout methodology, integrated system architectures, timing, testing future trends of VLSI technology. Graduate Staff

ECE 547 VLSI Architecture. *Preqs.: ECE 401, ECE 446. 3(3-0) F.* Study of algorithms and special purpose architectures for applications that require high performance systems such as digital signal and image processing. Topics include computer arithmetic, systolic arrays, DSP chips, wavefront processors and VLSI system design. Graduate Staff

ECE 550 Power System Operation and Control. *Preqs.: ECE 305 or ECE 331, B average in ECE and MA. 3(3-0) F.* Fundamental concepts of economic operation and control of power systems. Real and reactive power balance. System components, characteristics and operation. Steady state and dynamic analysis of interconnected systems. Tieline power and load-frequency control with integrated economic dispatch. Grainger

ECE (PY) 552 Introduction to the Structure of Solids. *3(3-0) S.* (See physics.)

ECE (CSC) 558 Digital Image Processing. *Preqs.: ECE 401, ST 371, high-level programming capability. 3(3-0) Every yr.* Introduction to the basic techniques of image processing. Topics include image formation and perception, digitization, Fourier transform domain processing, restoration and tomographic reconstruction. Rajala, Trussell

ECE (CSC) 559 Pattern Recognition. *Preqs.: ECE (CSE) 514, ST 371, B average in ECE and MA. 3(3-0) S.* A study of image pattern recognition techniques and computer-based methods for scene analysis, including discriminate functions, fixture extraction, classification strategies, clustering and discriminant analysis. Applications and current research results will be covered. Snyder

ECE (CSC, IE, OR) 562 Computer Simulation Techniques. *3(3-0) F.* (See computer science.)

ECE (CSC) 571 Data Transmission/Communications. *Preqs.: CSE 454 or CSC 312 or ECE 340; CSE 459 or ECE 301. 3(3-0) S.* Deals with the principles and techniques of moving digital data through transmission facilities. To be covered: digital information representation; characteristics of channels; modulation and demodulation (MODEM) techniques; error detection and correction; line control procedure; circuit, message and packet switching; multiplexors and concentrators. Graduate Staff

ECE (CSC) 572 Computer Communications. *Preq.: CSC 312 or ECE 340 or CSE 454; Coreq.: B average in technical subjects. 3(3-0) F.* The purpose of this course is to enable the student to understand the principles, the control and operations and the potential of computer communication systems; to present techniques for topological design and analytic modeling of such systems; and to provide the foundation for more detailed studies and research. The courses are self-contained and focus on practical applications of state-of-art techniques. Graduate Staff

ECE (CSC) 573 Introduction to Computer Performance Modelling. *3(3-0) F.* (See computer science.)

ECE (CSC, IE) 575 Voice Input/Output Communication Systems. *3(3-0) F.* (See industrial engineering.)

ECE (CSC) 574 Real Time Computer Systems. *3(3-0) Alt. S.* (See computer science.)

ECE 591, 592 Special Topics in Electrical Engineering. *Preq.: B average in technical subjects. 3(3-0) F,S.* A two-semester sequence to develop new courses and to allow qualified students to explore areas of special interest. Graduate Staff

ECE 593 Individual Topics in Electrical Engineering. *Preq.: B average in technical subjects. 1-3 F,S.* A course providing an opportunity for individual students to explore topics of special interest under the direction of a member of the faculty. Graduate Staff

FOR GRADUATES ONLY

ECE 601 Analog VLSI. *Preq.: ECE 511. 3(3-0) S.* A survey of advanced topics in very large-scale analog circuits (VLSI). The course provides in-depth coverage of analog-to-digital and digital-to-analog conversion, and switched-capacitor and other monolithic filtering techniques. Brief coverage is provided of special circuits for telecommunications and biomedical applications. Graduate Staff

ECE 603 Computer-aided Circuit Analysis. *Preq.: ECE 511. 3(3-0) F.* Steady state and transient analysis of circuits with emphasis on circuit theory and computer methods. Many analysis techniques are considered, including linear nodal, signal flow graph, state equation, time-domain and functional simulation and analysis of sampled data systems. Also included are sensitivity and tolerance analysis, macromodeling of large circuits, and nonlinear circuit theory. Steer

ECE 613 Advanced Feedback Control. *Preq.: ECE 516. 3(3-0) S.* The study of advanced topics in dynamical systems and multivariable control. Current research and recent developments in the field will be treated. Chow

ECE 619 Microwave Circuits Design. *Preq.: ECE 532. 3(3-0) S. Alt. yrs.* Techniques for the design of microwave and millimeterwave components and systems developed and examined. Radar and radiometer systems introduced and discussed. System-imposed constraints upon component performance investigated. Specific topics include mixer, oscillator and amplifier performance and design. Modern computer-aided design techniques used. Trew

ECE 622 Electronic Properties of Solid-State Materials. *Preq.: ECE 530. 3(3-0) S.* A review of energy bands in semiconductors. Detailed treatment of thermal and electrical transport phenomena, equilibrium and non-equilibrium semiconductor statistics. Also optical properties and hot electron effects in solid-state materials. Kolbas

ECE 623 Optical Properties of Semiconductors. *Preq.: ECE 530. 3(3-0) F. Alt. yrs.* Materials and device-related properties of compound optical semiconductors studied. Included topics are: optical constants, absorption and emission processes in semiconductors, photodetectors, LED's semiconductor lasers. Kolbas

ECE 624 Electronic Properties of Solid-State Devices. *Preq.: ECE 530. 3(3-0) S.* A study of the basic physical phenomena responsible for the operation of solid-state devices. The semiconductor equations examined and utilized to explain basic principles of operation. Rectifying and ohmic contacts examined. Various state-of-the-art devices studied in detail. Wortman

ECE 625 Advanced Solid-State Device Theory. *Preq.: ECE 624. 3(3-0) F.* A study of the latest developments in solid-state devices. Topics selected from subjects of current interest and state-of-the-art results discussed. Emphasis on the basic fundamental physical principles of operation as opposed to circuit applications. Wortman

ECE (PY) 627 Semiconductor Thin Films Technology. *Preq.: ECE 530. 3(3-0) S. Alt. yrs.* Techniques and processes encountered in the growth and characterization of epitaxial semiconductor films. Examples of growth techniques to be considered are: solution growth, chemical vapor deposition, molecular beam epitaxy and sputtering. Film characterization includes electrical characterization using Hall techniques, optical characterization using x-ray and electron microscopy techniques, surface and thin film analysis such as auger and secondary ion mass-spectrometer. Bedair

ECE 628 Preparation of Electronic Materials. *Preq.: ECE 530. 3(3-0) S. Alt. yrs.* A study of the principles governing the preparation of the electronic materials from the solid, liquid and gaseous states. Emphasis given to the experimental methods and to factors which affect the electronic behavior of materials, such as non-stoichiometry, charged and uncharged defects. Reisman

ECE 629 Growth of Thin Films from the Vapor Phase. *Preq.: ECE 530. 3(3-0) S. Alt. yrs.* Practical and basic aspects of single and polycrystal growth using chemical vapor transport processes. Emphasis on materials of interest in microelectronics and on experimental methods used to implement chemical vapor processes and to understand chemical vapor processes. Reisman

ECE 632 Power System Stability and Control. *Preqs.: ECE 451, ECE 516. 3(3-0) S.* Modeling of synchronous machines and their control systems. Coupled electric circuit approach, Park's transformations, additional rotor windings. Rudiments of dynamic and transient stability. Excitation systems, governor-control systems, power-system stabilizers. State space formulations for computer-based dynamic studies. Lubkeman

ECE 633 Computer Analysis of Large-Scale Power Systems. *Preq.: ECE 550. 3(3-0) F.* Computer-based matrix methods of analysis of large networks. Problem statements, algorithmic formulations and solution techniques emphasizing efficient use of the computer for short-circuit calculations, computations of power flows under normal and emergency conditions and stability studies. Linear programming and optimization methods in power system planning. Lubkeman

ECE (CSC) 640 Parallel Processing. *Preq.: CSE 506. 3(3-0) S.* Pipeline and vector computers, SIMD computers and performance enhancement, multiprocessing control and algorithms, example multiprocessors, data flow computer, VLSI-based architecture, recent research papers in parallel processing area. Agrawal

ECE (CSC) 641 Sequential Machines. *Preq.: ECE (CSE) 520. 3(3-0) F.* The study of finite automata, both synchronous and asynchronous. Machine equivalence and minimization, state identification and the state assignment problem. Flip-flop activation from the state diagram and other realization techniques. Graduate Staff

ECE 642 Automata and Adaptive Systems. *Preq.: ECE (CSE) 520. 3(3-0) S.* The study of neural nets in natural systems, artificial nerve nets, artificial intelligence, goal-directed behavior, the logic of automata and adaptive Boolean logic. Computability, Turing machines and recursive function theory. Graduate Staff

ECE 643 Advanced Computer Architecture. *Preq.: ECE 640. 3(3-0) F.* Multiprocessor interconnection and performance evaluation, multicomputer interconnections and associated problems, other architectural considerations, VLSI and computer architecture, application-directed architecture and case studies. Agrawal

ECE 647 Multidimensional Digital Signal Processing. *Preq.: ECE 513. 3(3-0) F.* A study of multidimensional signal processing techniques and algorithms. Topics include multidimensional transforms, multidimensional digital filters, computational structures for implementation of multidimensional systems and multidimensional filter design. Rajala

ECE 650 Design Automation for VLSI. *Preq.: CSE 505. 3(3-0) S.* VLSI CAD (computer-aids-to-design) tools research: physical design automation—layout, module generator, silicon compiler; logical design automation—CAD language, synthesis; simulation—circuit level, switch level, logic level, functional level; optimization techniques: graph theory, simulated annealing. W. Alexander

ECE (CSC) 651 Statistical Communication Theory. *Preq.: ECE (CSE) 514 or MA (ST) 541. 3(3-0) S.* Waveform analysis including Fourier transforms, correlation functions and other statistical descriptions of stationary and non-stationary random processes. Weiner theory: prediction, estimation and smoothing of discrete and continuous signals; introduction to Kalman filtering; problems to illustrate the applications of the theory to speech, television and data communication systems. Graduate Staff

ECE (CSC) 652 Information Theory. *Preq.: ECE (CSE) 514. 3(3-0) F. Alt. yrs.* Definition of a measure of information and a study of its properties, information sources and their efficient representation, communication channels and their capacity, encoding and decoding of data for transmission over noisy channels, source encoding systems, error correcting codes, rate distortion bounds. Ardalan

ECE (CSC) 659 Computer Vision. *Preqs.: MA 501 and MA 502. 3(3-0) F.* Analysis of images by computers. Specific attention is given to analysis of the geometric features of objects in images, such as region size, connectedness and topology. Topics covered include: segmentation, template matching, motion analysis, boundary detection, region growing, shape representation, 3-D object recognition including graph matching. Luo, Snyder

ECE (CSC) 671 Advanced Computer Performance Modelling. *3(3-0) S.* (See computer science.)

ECE (CSC, IE) 675 Advances in Voice Input/Output Communication Systems. *3(2-3) S.* (See industrial engineering.)

ECE 691, 692 Special Studies in Electrical Engineering. *3(3-0) F, S.* An opportunity for small groups of advanced graduate students to study topics in their special fields of interest under the direction of members of the graduate faculty. Graduate Staff

ECE 693 Individual Studies in Electrical Engineering. *Preq.: Grad. standing. 1-3 F, S.* The study of advanced topics of special interest to individual students under the direction of faculty members. Graduate Staff

ECE 699 Electrical Engineering Research. *Preqs.: Grad. standing in ECE, consent of advisor. Credits arranged.* Graduate Staff

Engineering

These courses are designed for use by graduate students in any department in the School of Engineering.

E (MA, OR) 531 Dynamic Systems and Multivariable Control I. *3(3-0) F.* (See operations research.)

E (MA, OR) 631 Dynamic Systems and Multivariable Control II. *3(3-0) S. Alt. yrs.* (See operations research.)

English

GRADUATE FACULTY

Professor J. E. Bassett, Head

Associate Professor J. M. Grimwood, Associate Head

Professor M. S. Reynolds, Director of the Graduate Program

Professors: B. H. Baines, P. E. Blank Jr., L. S. Champion, J. D. Durant, J. A. Gomez, M. Halperen, A. H. Harrison, M. T. Hester, K. F. C. Holloway, A. S. Knowles, L. H. MacKethan, W. E. Meyers, J. J. Smoot, A. F. Stein, W. B. Toole III, J. N. Wall Jr., M. C. Williams, R. V. Young Jr.; *Adjunct Professor:* D. D. Short; *Professors Emeriti:* H. G. Kincheloe, B. G. Koonce Jr., F. H. Moore, P. Williams Jr.; *Associate Professors:* G. W. Barrax, L. J. Betts Jr., E. D. Clark Sr., J. W. Clark Jr., D. H. Covington, J. Ferster, H. A. Hargrave, L. T. Holley, J. J. Kessel, M. F. King, D. L. Laryea, C. R. Miller, C. E. Moore, C. A. Prioli, L. S. Rudner, L. Smith, H. C. West, D. B. Wyrick; *Adjunct Associate Professor:* E. D. Engel; *Associate Professor Emeritus:* E. P. Dandridge Jr., N. G. Smith; *Assistant Professors:* M. P. Carter, B. A. Fennell, C. G. Herndl, S. B. Katz, D. C. Miller, A. M. Penrose, J. O. Pettis

The Department of English offers instruction leading to the Master of Arts in English, with coursework in English and American literature, rhetoric and composition, linguistics, and creative writing. The master's program can serve either as a complete course of study or as the first year of study toward a doctoral degree at another institution. A minimum of 30 semester hours of graduate credit is required, although some program options may require additional course work.

The M.A. program requires all students to take a distribution of four courses, one each in English literature before 1660, English literature after 1660, American literature, and a fourth category including composition theory, rhetoric, linguistics, and literary theory. In addition, all students must take an introduction to research and bibliography, pass a language requirement, take a comprehensive written examination, write a thesis and pass an oral exam on the thesis research.

Beyond these basic requirements, the program permits several emphases. Students interested primarily in the study of literature take additional courses in literature for a total of eight courses. Students interested in creative writing may substitute a workshop in creative writing for one literature course and present a

creative work or series of short works as their thesis. Students interested in the study and teaching of writing may take the composition concentration, which requires specific courses in composition, rhetoric and linguistics; the thesis is on a topic in one of these areas.

The department offers two options for students who hold "A" certification from the N. C. Department of Public Instruction. The M.A. with Graduate ("G") Certification requires 30 semester hours of graduate credit in English, as outlined above, and 9 semester hours of graduate credit in education. The M.A. with Sixth-Year Certification requires 60 semester hours of graduate study beyond the bachelor's degree, with course work in English, education and electives.

Teaching assistantships are available for promising students. These students take ENG 504 in the fall semester and, under the supervision of experienced teachers, devote half time in subsequent semesters to teaching freshman composition. ENG 504 gives graduate credit but does not count toward fulfillment of degree requirements.

Students and faculty in the Department of English are eligible for fellowships to participate in programs sponsored by the Folger Institute of Renaissance and Eighteenth-Century Studies, which is located in Washington, D.C., at the Folger Shakespeare Library. The Department also supports the publication of two journals edited by faculty members, *The John Donne Journal*, which publishes scholarship on Renaissance and seventeenth-century literature, and *Obsidian II: Black Literature in Review*, which publishes both creative and scholarly work.

Applicants to the M.A. program should submit GRE scores (general exam) and a writing sample. Undergraduate preparation should include 24 semester hours in English, with 12 of these hours in upper-division literature courses.

Technical Communication

Associate Professor C. R. Miller, Coordinator

The Master of Science in Technical Communication is designed to prepare professional communicators for advanced positions in industry and research organizations; with appropriate electives, students can prepare for careers in software documentation, environmental communication, industrial training in writing and editing, publications management and related areas. The program requires 33 semester hours: four courses in English (in the fields of writing, rhetoric and linguistics), one in communication, one in visual media, one in technical methods and three electives selected to complement the student's professional goals. Students must also satisfy a requirement for one semester of professional work experience, submit a thesis based on a supervised research project and pass an oral exam based on the thesis. Prerequisites for the program are basic editing, technical writing and computer literacy (ENG 214, ENG 331 and CSC 200). Applicants should submit GRE scores (general exam) and a writing sample.

FOR GRADUATES AND ADVANCED UNDERGRADUATES

NOTE: The prerequisite for all 500-level English courses is upper division or graduate standing.

ENG 504 Problems in College Composition. *Preq.: Grad. standing. 3(3-0) F.* Study of the history and theory of rhetoric; practice in writing and in literary analysis; preparation for the profession of teaching composition and literature. Required of all teaching assistants in English.
Baines, Grimwood, MacKethan

ENG 515 American Colonial Literature. *3(3-0) Alt. yrs.* Survey of American literature and thought from the beginning to the adoption of the constitution. Representative works such as travel and exploration reports, Indian captivity narratives, diaries, journals, autobiographies, sermons and poetry.
J. Clark, Prioli

ENG 521 Advanced Technical Writing and Editing. *Preqs.: ENG 214 and 321. 3(2-1) F.* Advanced study of specialized documents, technical editing and publications management for students planning careers in writing and editing. Course covers software documentation, manuals, indexing, style manuals, document design, legibility, readability testing, computerized production, on-screen documentation, desk-top publishing and publications management issues such as staffing, scheduling, cost-reduction, ethics and subcontracting.
Covington

ENG 524 Introduction to Linguistics. *Preq.: Grad. standing or 12 hours in ENG. 3(3-0) F.* Introduction to theoretical linguistics, especially for students in language, writing and literature curricula. Phonology, syntax, semantics, history of linguistics; relation of linguistics to philosophy, sociology and psychology; application of theory to analysis of texts.
Fennell, Meyers

ENG 525 Variety in Language. *Preq.: Grad. standing or 12 hours in ENG. 3(3-0) S.* Variety in the use of language, with particular emphasis on American English. Regional dialects; sociolinguistic issues related to class and gender; bilingualism; language and ethnicity; Black English and Hispanic English; basics of discourse analysis.
Fennell, Holloway

ENG 548 Black American Literature. *3(3-0) F.* Survey of black American literature and its relationships to culture from its beginnings to the present. Representative works from the oral tradition, slave narratives, Washington-DuBois controversy and the Harlem Renaissance. Writers include Douglass, Washington, Dunbar, Chesnutt, DuBois, Johnson, Hughes, Toomer, Hurston, Wright and several more recent figures.
Holloway, Laryea, MacKethan, Pettis

ENG 561 Milton. *3(3-0) S.* An intensive reading of Milton with attention to background materials in the history and culture of seventeenth-century England.
Wall, Young

ENG 575 Southern Writers. *3(3-0) S.* A survey of the particular contribution of the South to American literature, with intensive study of selected major figures.
Grimwood, Laryea, MacKethan

ENG 578 English Drama to 1642. *Preqs.: ENG 261 and upper division or grad. standing. 3(3-0) F. Alt. yrs.* Study of English drama from its beginnings in cycle plays to the closing of the theaters. Emphasis is placed on Elizabethan and Jacobean drama, excluding Shakespeare.
Baines, Williams

ENG 579 Restoration and 18th-Century Drama. *3(3-0) S. Alt. yrs.* Intensive study of the English drama from 1660 to 1800.
Durant

ENG 588 Fiction Writing Workshop. *Preq.: ENG 488 or ENG 489 and CI. 3(3-0) F.* Advanced work in techniques of writing fiction for students with substantial experience in writing. Workshop sessions with students commenting on each other's work.

Kessell, L. Smith

ENG 589 Poetry Writing Workshop. *Preq.: ENG 488 or ENG 489 and CI. 3(3-0) S.* Advanced work in techniques of writing poetry for students with substantial experience in writing. Workshop sessions with students commenting on each other's work.

Barrax

FOR GRADUATES ONLY

NOTE: The prerequisite for all 600-level English courses is graduate standing unless additional prerequisites are noted.

ENG 604 Writing: Theory and Research. *3(3-0) F.* Contemporary theory about the writing process, text structures and the functions of discourse. Attention to the assumptions and results of different research methods: cognitive, ethnographic and discourse analysis. Covers theories and research results relevant to audience, invention, coherence, revision, literacy, relations between oral and written discourse, content (including but not emphasizing the classroom context).

Carter, Penrose

ENG 609 Old English Literature. *3(3-0) S. Alt. yrs.* An introduction to the language and literature of the Old English period (450-1100). Readings will be in the original and will include both poetry and prose.

Ferster

ENG 610 Middle English Literature. *3(3-0) S. Alt. yrs.* A study of major works of medieval English literature (exclusive of Chaucer) in the light of dominant intellectual and artistic traditions: emphasis is on four works: *Piers Plowman*, *Pearl*, *Sir Gawain and the Green Knight*, and Malory's *Morte d'Arthur*.

Ferster, Holley

ENG 620 16th-Century Non-Dramatic English Literature. *3(3-0) F.* A detailed survey of non-dramatic prose and verse of the sixteenth century against the background of Humanism with the consequent assimilation of classical and continental literary subjects and forms.

Blank, Hester, Wall

ENG 621 Rhetoric of Science and Technology. *Preq.: Grad. standing or PBS. 3(3-0) S. Alt. yrs.* Study of the relationships among rhetoric, scientific knowledge and technological development and of changes in how these relationships have been understood historically. Practice in critical analysis of scientific and technical discourse. Consideration of scientific and technical language and of public controversy concerning science and technology.

Katz, C. Miller

ENG 622 The Rhetoric of Written Discourse. *3(3-0) S.* Contemporary rhetorical theory and its development from classical rhetoric; emphasis on the differences between oral and written communication and the relevance of traditional theory to the purposes and constraints of writing. Special attention to current issues: the revival of invention, argumentation and truth, contributions of research in composition.

Carter, C. Miller

ENG 624 Modern English Usage. *Preq.: ENG 524. 3(3-0) F. Alt. yrs.* An intensive study of English grammar, with attention to new developments in structural linguistics and with emphasis on current usage.

Meyers

ENG 626 History of the English Language. *3(3-0) F. Alt. yrs.* A survey of the growth and development of the language from its Indo-European beginnings to the present.

Meyers

ENG 630 17th-Century English Literature. *3(3-0) S.* A close examination of the literature of England from 1600 to 1700 with emphasis on major literary figures and movements.

the development of important literary forms and genres, and the intimate relationship between the literature of this period and its philosophical, political and theological backgrounds. Hester, Wall, Young

ENG 640 History of Literary Criticism. *Preq.: Grad. standing or PBS status. 3(3-0) F.* Survey of the history of literary criticism from Antiquity to the early Modern period. Introduction to major theoretical definitions of literature and modes of practical criticism. Close study of Aristotle's *Poetics*, Sidney's *Apology for Poetry*, Pope's *Essay on Criticism*, Coleridge's *Biographia Literaria*, Eliot's essays and other landmark works in the development of literary criticism. Halperen, Holley, Young

ENG 641 Contemporary Literary Theory. *Preq.: Grad. standing or PBS status. 3(3-0) S.* Survey of major developments in twentieth century literary theory. Introduction to central concepts, issues and theorists in contemporary literary criticism. Examination of range of modern critical practices. Study of relations between literary theory and such adjacent disciplines as linguistics, anthropology, social theory, psychology and philosophy. Ferster, D. Miller

ENG 650 English Romantic Period. *3(3-0) F.* A detailed study of the six major romantic poets—Blake, Wordsworth, Coleridge, Byron, Shelley, and Keats; some attention as well to the political, social and literary background and to a few minor writers and critics. Harrison, D. Miller

ENG 651 Chaucer. *Preqs.: ENG 451 or equivalent and grad. standing. 3(3-0) F.* An intensive study of the Chaucer canon requiring independent research. Ferster, Holley

ENG 655 American Romantic Period. *3(3-0) F.* A study of the selected works of Poe, Hawthorne, Melville, Emerson, and Thoreau, with emphasis on their varied contributions to the literature and thought of the American romantic movement. Bassett, MacKethan, Stein, West

ENG 658 Studies in Shakespeare. *Preqs.: ENG 486 or ENG 487 or equivalent and grad. standing. 3(3-0) F, S.* An intensive study of a particular phase of the Shakespeare canon. Emphasis normally on one dramatic genre (tragedy, comedy, history), but occasionally the focus may be more limited. Students may register for credit for a maximum of six hours. Baines, Champion, Williams

ENG 660 Victorian Poetry and Critical Prose. *3(3-0) S.* Studies in the literature of Victorian England: 1837-1901; the major poets and essayists, movements and questions in their historical contexts, religious, political and aesthetic. Hargrave, Harrison, King

ENG 662 18th-Century English Literature. *3(3-0) F.* The major figures in English literature between 1660 and 1790 against the background of social, cultural and religious change. Durant, Moore, Wyrick

ENG 663 18th-Century English Novel. *3(3-0) S. Alt. yrs.* Selected British novels of the eighteenth century studied in relation to the history and development of the genre and in the light of available critical opinion past and present. Durant, Moore, Wyrick

ENG 664 Victorian Novel. *3(3-0) F. Alt. yrs.* The nineteenth-century British novel studied from the perspective of literary history and twentieth-century criticism. King

ENG 665 American Realism and Naturalism. *3(3-0) S.* Concentration on Whitman, Dickinson, Twain, James and Dreiser, with briefer attention to Howells, Crane, Norris and other realists and naturalists. Bassett, MacKethan, Stein, West

ENG 670 20th-Century British Prose. *3(3-0) F. Alt. yrs.* An examination of the works of the major British writers and literary movements of this century and their historical context, religious, political and aesthetic. Halperen, Knowles, Reynolds

ENG 671 20th-Century British Poetry. 3(3-0) *S. Alt. yrs.* The development of English poetry from the rebellion against Victorian and Pre-Raphaelite verse to the present post-war scene; special attention to Hardy, Yeats, Eliot, Auden and Thomas.

Halperen, Knowles, Reynolds

ENG 675 20th-Century American Prose. 3(3-0) *F. Alt. yrs.* An examination of representative American writers of the novel and short fiction.

E. Clark, Halperen, Knowles, Reynolds

ENG 676 20th-Century American Poetry. 3(3-0) *S. Alt. yrs.* The development of modern American poetry from the rebellion against the romantic and genteel verse of the 1890's; special attention to Robinson, Frost, Pound, Williams, Stevens and Ransom.

Bassett, Halperen, Knowles, Reynolds

ENG 680 20th-Century British Drama. 3(3-0) *F. Alt. yrs.* A survey of modern British drama from its beginnings at the turn of the century to the present.

Halperen, Knowles

ENG 681 20th-Century American Drama. 3(3-0) *F. Alt. yrs.* A survey of modern American drama centering on major figures.

Halperen, Knowles

ENG 691 Special Topics in Written Communication. *Preq.: One 200-level writing course.* 3(3-0) *S.* Intensive study of issues in written communication, with special emphasis on application of theory to problems in a variety of areas. Seminar discussions and independent research.

Graduate Staff

ENG 692 Special Topics in American Literature. *Preq.: Consent of seminar chairman.* 3(3-0) *F.S.* An intensive study, involving independent research and centering on some limited topics from American literature.

Graduate Staff

ENG 693 Special Topics in English Literature. *Preq.: Consent of seminar chairman.* 3(3-0) *F.S.* An intensive study, involving independent research and centering on some limited topic from English literature.

Graduate Staff

ENG 698 Bibliography and Methodology. 1-3. Intensive study of the bibliography and methodology of literary research. Required of all graduate students in English.

Graduate Staff

ENG 699 Research in Literature (Thesis). *Preq.: Consent of graduate adviser. Credits Arranged.* *F.S.* Independent investigation of an advanced literary or linguistic problem leading to the writing of a master's thesis.

Thesis Director

Entomology

GRADUATE FACULTY

Professor J. D. Harper, *Head*

Professor: H. H. Neunzig, *Graduate Administrator*

Professors: J. T. Ambrose, C. S. Apperson, R. C. Axtell, J. S. Bacheler, J. R. Baker, J. R. Bradley Jr., W. M. Brooks, W. V. Campbell, W. C. Dauterman, E. Hodgson, M. H. Farrier, F. P. Hain, G. G. Kennedy, R. J. Kuhr, J. R. Meyer, G. C. Rock, T. J. Sheets, K. A. Sorensen, P. S. Southern, R. E. Stinner, J. W. Van Duyn, C. G. Wright; *Adjunct Professors:* A. L. Chasson, J. R. Fouts, J. E. Gibson, J. A. Goldstein, F. L. Hastings, R. A. Neal, R. M. Philpot; *Professors Emeriti:* F. E. Guthrie, W. J. Mistic Jr., H. B. Moore Jr., R. L. Rabb, R. L. Robertson, D. A. Young Jr.; *Associate Professors:* J. J. Arends, R. L. Branden-

burg, L. L. Deitz, F. L. Gould, R. C. Hillmann, E. P. Lampert, B. M. Parker, R. M. Roe; *Associate Professor (USDA)*: D. M. Jackson; *Adjunct Associate Professors*: C. Y. Kawanishi, H. B. Matthews Jr.; *Assistant Professors*: G. J. House, R. C. Smart, J. F. Walgenbach; *Assistant Professor (USDA)*: D. W. Keever; *Adjunct Assistant Professor*: K. J. Giroux

ASSOCIATE MEMBERS OF THE DEPARTMENT

Associate Professors: B. C. Haning, H. M. Linker

The Department of Entomology* offers graduate training leading to the Master of Science, Master of Agriculture (non-thesis) and Doctor of Philosophy degrees. Major areas of specialization are agricultural entomology, apiculture, behavior, ecology, forest entomology, host-plant resistance, invertebrate pathology, medical and veterinary entomology, nutrition, pesticide analysis, pesticide fate in soil and water, pest management, physiology, population dynamics, soil entomology, systems analysis, taxonomy and toxicology.

Opportunities exist for training in both applied and fundamental phases of entomology. Population management concepts are emphasized in the applied entomology and pest management programs. The applied phases are influenced by the State's agriculture, in which corn, tobacco, cotton, peanuts, soybeans, small grains, fruits, vegetables, livestock and forestry are important components. The rapidly expanding tourist industry and the diverse habitats of the State, extending from the mountains to the sea, provide unique opportunities for research on insects and related arthropods affecting man. A cooperative arrangement with the College of Forest Resources provides majors in forest entomology. The program in medical and veterinary entomology includes both applied and fundamental research and provides the opportunity for training at the School of Public Health, UNC, Chapel Hill. Students electing graduate work in entomology are expected to have strong backgrounds in biological sciences, chemistry and mathematics. Undergraduate preparation in entomology is not required.

Strong interdepartmental programs in ecology, physiology and toxicology include faculty members from the Department of Entomology and provide graduate training for entomology students desiring interdisciplinary graduate degrees. Additionally, interinstitutional courses are available on the nearby campuses of Duke University and the University of North Carolina at Chapel Hill. The presence of numerous federal and industry laboratories in the nearby Research Triangle Park further enhances entomology graduate training.

The departmental research, extension and training programs are housed in a complex of facilities including a pesticide residue research laboratory, biochemistry and toxicology laboratories, insect rearing rooms, greenhouses and field stations. An adjacent phytotron or bioclimatic facility provides an opportunity for ecological and behavioral studies under controlled conditions. Ultrastructural investigations are conducted in the electron microscope facility of the College of Agriculture and Life Sciences. Extensive computer facilities and statistical services are available in the department and on campus.

See a description of the Pesticide Residue Research Laboratory elsewhere in this bulletin.

*This department does require GRE scores.

SELECTED ADVANCED UNDERGRADUATE COURSES

ENT (ZO) 425 General Entomology. *Preq.: ZO 201 or equivalent. 3(2-3) F, Sum.*

Related Course:

PM 415 Principles and Systems of Integrated Pest Management. *Preqs.: BO (ZO) 360, PP 315, ENT 312; Coreq.: CS 414. 4(3-3) S.*

FOR GRADUATES AND ADVANCED UNDERGRADUATES

ENT 502 Insect Diversity. *Preq.: ENT 425 or equivalent. 4(2-4) F.* Surveys the diversity of insect biology and structure emphasizing the identification of adults; includes speciation, evolutionary relationships, approaches to classification, nomenclature, zoogeography and techniques of collection. Deitz

ENT 503 Functional Systems of Insects. *Preqs.: Twelve hrs. of biology, nine hrs. of CH, three hrs. of BCH. 4(3-3) S.* The morphology, histology and function of the organ systems of insects. Basic physiological principles discussed in the context of insect growth and development. The laboratory designed to give students practical experience with modern physiological techniques. Roe

ENT (ZO) 509 Ecology of Stream Invertebrates. *4(2-6) S.* (See zoology.)

ENT 520 Insect Pathology. *Preqs.: ENT 425 and MB 401 or equivalent. 3(2-3) S. Alt. yrs.* A treatment of the noninfectious and infectious diseases of insects, the etiological agents and infectious processes involved, immunological responses and applications. Brooks

ENT 531 Insect Ecology. *Preqs.: ENT 425 and BO (ZO) 560 or equivalent. 3(2-2) F. Alt. yrs.* The interrelationships among insects and components of their effective environments which result in dynamic spatial and temporal patterns of particular species. Also, the diverse roles of insects in the structure and function of communities and ecosystems. Gould

ENT 541 Immature Insects. *Preq.: ENT 502 or equivalent. 3(1-4) F. Alt. yrs.* Biology and taxonomy of immature insects with emphasis on identification of the larval stage of endopterygote orders. A collection of immatures and associated reared adults is required. Neunzig

ENT 550 Fundamentals of Insect Control. *Preq.: ENT 312 or 301. 3(2-2) F.* The principles underlying modern methods for protecting food, clothing, shelter and health from insect attack. Lampert

ENT 562 Insect Pest Management in Agricultural Crops. *Preq.: ENT 550. 3(3-0) S. Alt. yrs.* Critical review of the biology and ecology of representative beneficial and injurious insects and arachnids of agricultural crops and the advantages and limitations of advanced concepts of their management in selected agroecosystems. Bradley, Kennedy, Rock

ENT (FOR) 565 Advanced Forest Entomology. *Preq.: ENT 301 or ENT 502 or CI. 3(2-2) S. Alt. yrs.* Covers the important insect pests of forest and shade trees including regeneration pests, defoliating insects, inner-bark borers, wood borers, sucking insects, and bud, twig and root feeding insects. Also includes concepts in forest pest management and population dynamics. Hain

ENT (ZO) 582 Medical and Veterinary Entomology. *Preqs.: ENT 312 or 425 and ZO 315 or equivalent. 3(2-3) S. Alt. yrs.* The morphology, taxonomy, biology and control of the arthropod parasites and disease vectors of man and animals. The ecology and behavior of vectors in relation to disease transmission and control. Axtell

ENT 590 Special Problems. *Preq.: CI. Credits Arranged. F,S.* Original research on special problems in entomology not related to a thesis problem. Provides experience and training in research. Graduate Staff

ENT 591 Special Topics in Entomology. *Preq.: Grad. standing. 1-3 F,S.* A variable credit lecture and laboratory series offering topics such as morphology, physiology, systematics, behavior, biological control, urban and stored product pests, nursery and ornamental pests, host plant resistance, information retrieval, biological monitoring and sampling, population modelling, extension entomology and computer methods. Graduate Staff

ENT 592 Agricultural Entomology Practicum. *Preq.: Economic entomology (ENT 562 recommended). 3(0-9) Sum. Alt. yrs.* Practical experience in research, extension and commercial aspects of insect pest management on a broad range of agricultural crops under actual field conditions. Class meets 9 hours each Friday for 10 weeks from early June to mid-August. Students should register for second summer session. Bradley

FOR GRADUATES ONLY

ENT 622 Insect Toxicology. *Preqs.: ENT 550, BCH 551 or equivalent. 3(2-3) S. Alt. yrs.* The relation of chemical structure to insect toxicity, the mode of action of toxicants used to kill insects, the metabolism of insecticides in plant and animal systems, the selectivity within the cholinesterase inhibitors and other selective mechanisms and the analysis of insecticide residues will be discussed. Dauterman

ENT 690 Seminar. *Preq.: Grad. standing in ENT or closely allied fields. 1(1-0) F,S.* Discussion of entomological topics selected and assigned by seminar chairman. Graduate Staff

ENT 699 Research. *Preq.: Grad. standing. Credits Arranged. F,S.* Original research in connection with thesis problem in entomology. Graduate Staff

Fiber and Polymer Science

ASSOCIATED GRADUATE FACULTY

Professor S. P. Hersh, Chairman and Program Director

Professors: R. L. Barker, S. K. Batra, K. R. Beck, D. R. Buchanan, J. A. Cuculo, A. H. M. El-Shiekh, R. E. Fornes, H. S. Freeman, R. D. Gilbert, P. L. Grady, B. S. Gupta, H. B. Hopfenberg, C. D. Livengood, P. R. Lord, R. McGregor, G. N. Mock, M. H. M. Mohamed, H. G. Olf, M. H. Theil, C. Tomasino, P. A. Tucker, C. F. Zorowski; *Adjunct Professors:* J. E. Hendrix, H. F. Mark; *Professors Emeriti:* J. F. Bogdan, D. M. Cates, D. W. Chaney, T. W. George, D. S. Hamby, H. A. Rutherford, V. T. Stannett, W. C. Stuckey Jr., W. K. Walsh, W. M. Whaley, R. W. Work; *Associate Professors:* T. J. Little, C. B. Smith; *Associate Professors Emeriti:* T. H. Guion, T. G. Rochow; *Assistant Professors:* P. Banks-Lee, A. C. Clapp, T. G. Clapp, H. Hamouda, S. M. Hudson, J. W. Rucker; *Visiting Assistant Professor:* T. K. Ghosh

Fiber and polymer science is a multidisciplinary program bringing together the disciplines of mathematics, chemistry and physics and the application of engineering principles for the development of independent scholars versed in the field of fiber materials science. The program is administered by the College of Textiles and leads to the degree of Doctor of Philosophy. Students majoring in the

physical sciences, mathematics, textiles or engineering and having at least a "B" grade in their undergraduate major will normally qualify for admission.

Fiber and polymer science is concerned with polymeric materials, fibers produced from them, fiber assemblies in one-, two- and three-dimensional forms and chemical modification of fiber assemblies. This broad field of study permits a wide range of useful concentrations. The candidate is expected to penetrate deeply into one area of specialization and to acquire a reasonable perspective in other relevant subject matter. Generally specialization occurs within the area of (1) polymer chemistry and synthesis, (2) fiber and polymer physics and physical chemistry, (3) structural mechanics of textile materials, (4) formation and processing of fibers and fibrous textile structures or (5) dyeing and chemical modification of textile materials. The student's research is based within one of these areas.

Ample laboratory space is available and there are a number of specialized laboratories equipped to support doctoral investigations. Other facilities and research equipment which may be used in fiber and polymer science research programs are available in cooperating departments on campus. The Burlington Textiles Library houses one of the most complete collections of polymer, fiber and textile literature.

DEGREE REQUIREMENTS

Doctor of Philosophy—An advisory committee chaired by a member of the fiber and polymer science faculty is formed as soon as possible to develop with the student a plan of study designed to enable one to acquire the comprehensive knowledge required to pass the qualifying cumulative examinations.

There are no definite requirements in credit hours for the Doctor of Philosophy degree. A student's program of study is designed around the student's special interests, while maintaining the coherence and breadth essential for professional development and excellence in research. A reading knowledge of one foreign language is required.

Doctor of Philosophy Minor—Ph.D. candidates who designate a named minor in fiber and polymer science will be required to take nine credit hours in related courses approved by the minor representative on the student's advisory committee.

Communications concerning this program should be directed to the Chair of the Committee for the Fiber and Polymer Science Program, College of Textiles, North Carolina State University.

COURSE OFFERINGS*

(See departmental listing for descriptions.)

GENERAL COURSES

T 402 Introduction to the Theory and Practice of Fiber Formation.

TC (CH) 461 Introduction to Fiber-Forming Polymers.

*Extensive use may be made of graduate course offerings in other schools on campus when developing the minor field.

TC 504 Fiber Formation—Theory and Practice.

TC (CH, MAT) 562 Physical Chemistry of High Polymers—Bulk Properties.

TES 500 Fiber and Polymer Microscopy.

TES 505 Textile Instrumentation and Control Systems.

TES 561 Mechanical and Rheological Properties of Fibrous Material.

TES (MAT) 563 Characterization of Structure of Fiber Forming Polymers.

TC 591 Special Topics in Textile Science.

TES (TC) 691 Special Topics in Fiber Science.

COURSES IN AREAS OF SPECIALIZATION

Polymer Chemistry and Synthesis

TC 520 Chemistry of Dyes and Color.

TC 521 Dye Synthesis Laboratory.

TC 530 The Chemistry of Textile Auxiliaries.

TC 561 Organic Chemistry of High Polymers.

TC (CHE) 671 Special Topics in Polymer Science.

Polymer Physics and Physical Chemistry

TES 500 Fiber and Polymer Microscopy.

TC 504 Fiber Formation—Theory and Practice.

TC 505 Theory of Dyeing.

TC (CH, MAT) 562 Physical Chemistry of High Polymers—Bulk Properties.

TC (CH, MAT) 662 Physical Chemistry of High Polymers—Solution Properties.

TC (CHE) 569 Polymers, Surfactants and Colloidal Materials.

TC (CHE) 570 Radiation Chemistry and Technology of Polymeric Systems.

TC (CHE) 669 Diffusion in Polymers.

TES 562 Physical Properties of Fiber Forming Polymers, Fibers and Fibrous Structures.

TES (TC) 691 Special Topics in Fiber Science.

Mechanics of Textile Materials and Processes

TES 520 Yarn Processing Dynamics.

TES 549 Warp Knit Engineering and Structural Design.

TES 555 Production Mechanics and Properties of Woven Fabrics.

TES 640 Physical and Mechanical Properties of Knitted Fabrics.

TES 663 Mechanics of Twisted Structures.

TES 664 Mechanics of Fabric Structures.

Food Science**GRADUATE FACULTY***Professor D. R. Lineback, Head**Professor V. A. Jones, Graduate Administrator*

Professors: H. R. Ball Jr., R. E. Carawan, D. E. Carroll Jr., G. L. Catignani, H. B. Craig, M. E. Gregory, D. D. Hamann, H. M. Hassan, H. N. Jacobson, T. R. Klaenhammer, T. C. Lanier, J. L. Oblinger, H. E. Swaisgood, K. R. Swartzel, F. R. Tarver Jr., C. T. Young; *Professors (USDA):* H. P. Fleming, R. F. McFeeters, W. M. Walter Jr.; *Adjunct Professor:* R. A. Neal; *Professors Emeriti:* L. W. Aurand, T. A. Bell, T. N. Blumer, E. S. Cofer, M. W. Hoover, I. D. Jones, W. M. Roberts, M. L. Speck, F. B. Thomas, F. G. Warren; *Associate Professors:* E. A. Foegeding, P. M. Foegeding, A. P. Hansen, D. H. Pilkington, J. E. Rushing, S. J. Schwartz, B. W. Sheldon, L. G. Turner, D. R. Ward; *Assistant Professors:* J. C. Allen, L. C. Boyd, D. K. Larick; *Visiting Research Assistant Professor:* N. A. Klapes

Programs of study leading to the Master of Agriculture, Master of Life Sciences, Master of Science and Doctor of Philosophy degrees are offered by the Department of Food Science.

Areas of study and research include food chemistry, food microbiology, food engineering, nutrition and food process and product development. These areas involve all foods including dairy products, fruits, meats, poultry products, seafood, nutmeats and vegetables. Supporting course work and cooperative research are offered in areas such as biochemistry, chemistry, engineering, genetics, microbiology, nutrition, toxicology and biotechnology.

Because of the diversity of disciplines and wide range of opportunities in food science, each student and his/her advisory committee are granted considerable flexibility in developing a graduate program tailored to the student's interests and research needs. Each program must conform to guidelines of the Graduate School (see Graduate Programs) and food science policies and procedures (available from the Department of Food Science). All graduate students are eligible for assignment as teaching assistants in food science courses. The Master of Science program requires a minimum of 30 semester hours of work including a thesis.

The Master of Agriculture and Master of Life Sciences programs require a minimum of 36 semester hours; no thesis is required, but at least four semester hours of special problems are required. There are no requirements for 600-level courses in the Master of Agriculture and Master of Life Sciences programs. The total semester hours of work for the Ph.D. degree are established by the advisory committee to meet the objectives of the student's program. No foreign language is required.

The department participates in interdepartmental graduate student training programs such as marine science, toxicology, biotechnology and nutrition.

Excellent laboratory, pilot plant, library and computer facilities, as well as graduate assistantships, are available to support qualified candidates.

SELECTED ADVANCED UNDERGRADUATE COURSES

FS 400 Foods and Nutrition. *Preq.: CH 220. 3(3-0) F.*

FS 402 Food Chemistry. *Preq.: CH 220 or CH 221. 3(2-3) F.*

FS (MB) 405 Food Microbiology. *Preq.: MB 401. 3(2-3) F.*

FS 416 Quality Control of Food Products. *Preqs.: FS 402, MB 401. 3(2-3) S.*

FS 421 Food Preservation. *Coreq.: MB 401. 3(2-3) F.*

FS 423 Muscle Food Technology. *Preqs.: FS 322, FS 421, FS 402. 3(2-3) S.*

FS 425 Processing Dairy Products. *Preqs.: FS 324, FS 421. 3(2-3) S.*

FOR GRADUATES AND ADVANCED UNDERGRADUATES

FS 504 Food Proteins and Enzymes. *Preq.: FS 402 or BCH 451. 3(2-3) F. Alt. yrs.* An advanced course in food chemistry with emphasis on proteins and enzymes of particular importance to foods. Protein interactions and their effect on the physical-chemical characteristics of a product. Particular emphasis on the preparation and kinetic properties of immobilized enzymes and their use as biochemical reactors in processing operations or as specific electrodes for analytical purposes.

Swaigood

FS 511 Food Research and Development. *Preqs.: FS 331, FS 402, FS (MB) 405. 3(2-3) S.* A study of the scientific principles underlying the development of new and improved food products and processes. The study of specific food industry problems by the case method. Special emphasis on the application of research and development principles to meat, poultry and fisheries industries.

Lanier

FS (NTR) 530 Human Nutrition. *Preqs.: FS 400 or NTR 415 or 419; BCH 451. 3(3-0) S. Alt. yrs.* Biochemical and physiological bases of nutrition. Human nutrient requirements, assessment of nutritional status, clinical and subclinical disorders resulting from nutrient deficiencies or inadequacies.

Catignani

FS (HS) 562 Post-Harvest Physiology. *3(3-0) S.* (See horticultural science.)

FS 580 Food Kinetics. *Preqs.: FS 212, FS 402, FS 405, MA 212 or CI. 3(3-0) S. Alt. yrs.* Basic and applied kinetic principles, development and use of kinetic data of food components, food processing system design, system modeling, system evaluation and storage stability considerations.

Swartzel

FS (BAE) 585 Food Rheology. *Preqs.: FS 331 or MAE 314. 3(2-3) F.* Principles and methods for measuring rheological properties. Theories of elastic, viscous, viscoelastic and viscoplastic behavior and relationships to food texture and commodity damage during

harvest, handling and processing. Influence of time, composition and processing. Influence of time, composition and processing on rheological properties. Hamann

FS 591 Special Problems in Food Science. *Preq.: Grad. or sr. standing. Max. 6. F,S,Sum.* Analysis of scientific, engineering and economic problems of current interest in foods. The problems are designed to provide training and experience in research.

Graduate Staff

FOR GRADUATES ONLY

FS (NTR) 606 Vitamin Metabolism. *2(2-0) F.* (See nutrition.)

FS 680 Seminar in Food Science. *1(1-0) F,S.* Preparation and presentation of scientific papers, progress reports and research and special topics of interest in foods.

Graduate Staff

FS 691 Special Research Problems in Food Science. *Credits Arranged. F,S,Sum.* Directed research in a specialized phase of food science designed to provide experience in research methodology and philosophy.

Graduate Staff

FS 699 Research in Food Science. *Credits Arranged. F,S,Sum.* Original research preparatory to the thesis for the Master of Science or Doctor of Philosophy degree.

Graduate Staff

Foreign Languages and Literatures

GRADUATE FACULTY

Professor J. H. Stewart, Head

Professors: G. F. Gonzalez, J. R. Kelly, M. Paschal, G. G. Smith, M. A. F. Witt;
Professors Emeriti: A. A. Gonzalez, G. W. Poland, E. M. Stack; *Associate Professors:* A. C. Malinowski, E. W. Rollins Jr., S. E. Simonsen; *Associate Professor Emeritus:* H. Tucker Jr.; *Assistant Professor:* L. Mykyta

The Department of Foreign Languages and Literatures offers courses to assist graduate students in preparing to use modern foreign languages in research and advanced study. These courses are not open to undergraduates.

With special permission of the Graduate School, certification may be obtained in languages not normally taught by the department.

***FLF 401 French for Graduate Students.** *3(3-0) F.* Basic French grammar, with special attention to characteristics of formal expository style, and illustrative readings. Study of extracts from scholarly publications in the students' areas of research. Graduate language certification granted on satisfactory completion of the course.

***FLG 401 German for Graduate Students.** *3(3-0) F.* Basic German grammar, with special attention to characteristics of formal expository style, and illustrative readings. Study of extracts from scholarly publications in the students' areas of research. Graduate language certification granted on satisfactory completion of the course.

***FLS 401 Spanish for Graduate Students.** *3(3-0) F.* Basic Spanish grammar, with special attention to characteristics of formal expository style, and illustrative readings. Study of extracts from scholarly publications in the students' areas of research. Graduate language certification granted on satisfactory completion of the course.

*These courses are designed to be audited and credits do not apply toward advanced degrees.

Forestry

GRADUATE FACULTY

Professor A. W. Cooper, Head

Professor D. L. Holley Jr., Graduate Administrator

Professors: D. A. Adams, E. B. Cowling, C. B. Davey, H. A. Devine, P. D. Doerr, M. H. Farrier, E. C. Franklin, D. J. Frederick, L. F. Grand, W. L. Hafley, F. P. Hain, A. E. Hassan, R. C. Kellison, S. Khorram, R. L. Noble, L. C. Saylor, R. R. Sederoff, A. G. Wollum II; *Professor (USDA):* D. E. Moreland; *Professors (USFS):* F. E. Bridgwater Jr., G. Namkoong; *Adjunct Professors:* G. L. DeBarr, G. F. Dutrow, J. D. Hair, R. W. Stonecypher, C. G. Wells; *Professors Emeriti:* J. W. Duffield, J. O. Lammi, W. D. Miller, T. O. Perry, R. J. Preston, B. J. Zobel; *Associate Professors:* H. L. Allen Jr., H. V. Amerson, R. I. Bruck, J. D. Gregory, L. E. Hinesley, J. B. Jett Jr., J. G. Laarman, R. A. Lancia, R. Lea, R. R. Perdue, R. A. Powell, R. J. Weir, J. N. Woodman; *Adjunct Associate Professors:* D. L. Bramlett, R. G. Campbell, J. R. Jorgensen, *Assistant Professors:* R. R. Braham, L. J. Frampton Jr., S. E. McKeand, J. P. Roise, W. D. Smith, A.-M. Stomp; *Assistant Professor (USFS):* J. E. de Steiguer; *Adjunct Assistant Professors:* W. E. Ladrach, R. B. McCullough, G. A. Ruark, H. D. Smith; *Research Associate:* W. S. Dvorak; *Research Assistant Professors:* A. R. Gillespie, L. Tolley-Henry; *Extension Forest Resources Specialist:* E. J. Jones

The Department of Forestry offers graduate work leading to the degrees of Master of Forestry, Master of Science and Doctor of Philosophy. Because of the diversity of disciplines and the wide range of opportunities in forestry, each of these degrees allows considerable flexibility in developing programs of graduate study tailored to the student's objectives. In addition, graduate students in the Department of Forestry may pursue three interdisciplinary graduate degrees: Master of Wildlife Biology, Master of Science in wildlife biology and Master of Science in ecology.

The Master of Forestry is a professional degree designed to broaden and extend knowledge in the scholarly disciplines of forestry. The program emphasizes course work and application of principles. A thesis is not required. Two options are available: one requires 36 hours of course work and the other requires 30 hours plus a special project.

The Master of Science degree emphasizes training and experience in research. This degree typically leads to specialization in one of the disciplines of forestry. Requirements include 30 hours of course work and a thesis.

The Doctor of Philosophy degree is available to students who demonstrate outstanding intellectual capacity and the ability to conduct original research and scholarly work at the highest levels. There is no foreign language requirement and no specific credit hour requirement; however, the student's advisory committee will insist on a rigorous and appropriate program of study and research.

All applicants for graduate study in forestry must take the Graduate Record Examination General Test and submit scores as part of their application. Students not holding an undergraduate degree in forestry may be admitted for

graduate study, but they must lengthen their programs to obtain appropriate background courses in forestry.

The department offers graduate instruction in all of the major areas of forestry. The faculty has professional expertise and on-going research in the following areas: atmospheric impacts, biometrics, biotechnology and pine tissue culture, computer applications, ecology, economics, engineering, entomology, environmental impact assessment, forest management, genetics and tree breeding, hydrology and watershed management, international development, operations research, plant pathology, remote sensing and computer mapping, resource planning and administration, silviculture, soils and fertilization, tree physiology, wildlife biology, and wildlife management. Strong supporting departments on campus increase opportunities for broad and thorough training. Relationships with these departments are strengthened by many joint and associate faculty appointments. In addition, an adjunct faculty of 12 distinguished scientists and practitioners working in industry and government are available to serve on student advisory committees.

Facilities for forest biological research include a phytotron, greenhouses and a small experimental nursery. The experimental and production forests of the School total more than 80,000 acres. The Hofmann Forest on the Coastal Plain, the Goodwin Forest in the Sandhills, and the Schenck, Hope Valley and Hill Forests in the Piedmont provide a variety of forest types and problems in the management of timber, water, wildlife and recreational resources.

The department has formal research ties with forest industry and public agencies through its four research and development cooperatives (Tree Improvement, Hardwood Research, Forest Nutrition and Central America and Mexico Coniferous Resources), the Small Woodlot Research and Development Program, the Atmospheric Impacts Research Program, and the College's Forest Biology Research Center (which administers major projects on tissue culture, site productivity and forest biotechnology). Much of the department's research is conducted on forest industry lands in the Southeast. A significant number of faculty and graduate students are involved in tropical forestry projects.

Inquiries concerning graduate study should be directed to the Graduate Administrator, Department of Forestry, Box 8002, North Carolina State University, Raleigh, NC 27695-8002.

SELECTED ADVANCED UNDERGRADUATE COURSES

FOR 401 Forest Hydrology and Watershed Management. *Preq.: SSC 200. 4(3-3) F.*

FOR (FW) 404 Forest Wildlife Management. *Preqs.: BS 100 or equivalent plus 8 hours of biological sciences; advanced undergrad. or grad. student. 3(3-0) S.*

FOR 405 Forest Management. *Preqs.: FOR 319, 374; Coreq.: FOR 434. 4(2-4) F.*

FOR 406 Forest Inventory, Analysis and Planning. *Preqs.: FOR 273, 353, 405, ST 312. 4(0-16) S.*

FOR 411 Forest Tree Improvement. *Preq.: Jr. or sr. standing in FOR. 3(3-0) S.*

FOR 412 Forest Types of the Southeast. *Preq.: FOR 212. 2(1-3) S. Alt. yrs.*

FOR 422 Forest Business: Consulting and Procurement. *Preq.: Jr. standing in forestry. 3(2-2) S.*

FOR (WPS) 423 Forest Machinery and Systems. *Preq.: Jr. standing in FOR, WST or BAE. 3(2-3) F.*

FOR (WPS) 434 Decision Making in Forestry and Wood Products. *Preqs.: FOR (WPS) 273, MA 113 and 114, 3(3-0) F.*

FOR 472 Renewable Resource Policy and Management. *Preq.: Jr. standing. 4(3-2) S.*

FOR 491 Senior Problems in Forestry. *Preq.: Consent of department. 1-6.*

FOR GRADUATES AND ADVANCED UNDERGRADUATES

FOR 510 Quantitative Forest Genetics Methods. *Preqs.: GN 506, ST 512, 3(3-0) F. Alt. yrs.* Fundamental principles and procedures for partitioning experimental variance, estimating parameters of interest from different mating schemes and experimental designs and their uses in making tree breeding decisions. Bridgwater

FOR 511 Tree Improvement Research Techniques. *Preq.: FOR 411 or GN 411, 3(1-4) S. Alt. yrs.* Research methods involved in forest tree breeding and genetics programs. Emphasis placed on laboratory, greenhouse and field research techniques. Summary and presentation of research results also stressed. Jett, Zobel

FOR 512 Forest Economics. *Preq.: Basic course in economics. 3(3-0) S.* Economics applied to problems in forest management, including timber demand and supply models, optimal rotation length, benefit-cost analysis of forestry projects, impacts of forest taxation and consideration of non-market forest goods and services. Laarman

FOR (PP) 518 Advanced Forest Pathology. *3(3-0) Alt. F.* (See plant pathology.)

FOR 534 Advanced Forest Management Planning. *Preq.: FOR 405 or FOR 434 or OR 501; Coreq.: FOR 572A, 3(3-0) S. Alt. yrs.* History, principles, structures and use of modern forest management planning and decision-making techniques. Emphasis on optimization procedures and public forest management. Roise

FOR 540 Advanced Dendrology. *Preq.: BO 403 or FOR 212, 3(2-3) S. Alt. yrs.* Identification and life histories of native and naturalized woody plants. Use of taxonomic manuals and literature. Identification of problematic groups. Concentration on North America, with discussion of other continents. Overnight field trips to natural forest communities. Braham

FOR (ENT) 565 Advanced Forest Entomology. *3(2-2) S.* (See entomology.)

FOR 571 Advanced Topics in Growth and Yield. *Preqs.: FOR 272, ST 312, 3(3-0) S.* Development and application of site index, volume and forest yield models. Primary emphasis on underlying biological and mensurational assumptions and their impact on application. Hafley

FOR 572A,B Forest Management Policies on the Public Lands. *2(2-0) S. Alt. yrs.* History, development and current status of policies relating to forest management on the public lands. FOR 572A deals with history and policies through passage of the National Forest Management Act. FOR 572B deals with current issues. Students may enroll in either FOR 572A or FOR 572A and FOR 572B but not FOR 572B alone. Cooper

FOR 580 Soil-Machine Interactions in Forestry Operations. *Preq.: FOR 423, 3(3-0) F. Alt. yrs.* Mechanics of interactions between forestry soils and tillage and traction devices; determination of relevant physical properties of soil; analyses of stresses and strains in soil due to machine-applied loads; experimental and analytical methods for synthesizing characteristics of overall systems. Hassan

FOR 583 Tropical Forestry. *Preq.: Sr. standing. 3(3-0) S. Alt. yrs.* Principles of tropical ecology, dendrology and agroforestry. Establishment and management of tropical plantations and natural stands. Operation and management of tropical nurseries. Economics of the international forest products trade. Governmental regulations, policies and permit procedures. Davey, Laarman, Ladrach

FOR (UNI) 584 The Practice of Environmental Impact Assessment. *4(0-8) F. Alt. yrs.* Students (in teams) inventory natural resources in a large watershed, predict development at year 2000, analyze impact upon the natural resource base and compile results as an environmental impact assessment. Techniques include map and aerial photo interpretation, timber and wildlife habitat inventory, erosion estimation, curve fitting, technical writing, computer modeling and project organization and management. Adams

FOR (FW) 585 Advanced Wildlife Habitat Management. *Preqs.: ZO (FW) 553 and ZO (FW) 554. 3(2-3) S. Alt. yrs.* Assessing and modeling habitat capability for wildlife species discussed and evaluated. Students develop models of habitat requirements for wildlife species and integrate the models into wildlife management plans. Laboratory exercises include manipulation of habitat management computer packages and development of a wildlife management plan using computer cartographic techniques. Lancia

FOR 592 Special Topics in Forestry. *Credits Arranged. F,S,Sum.* Individual students or groups of students, under the direction of a faculty member, may explore topics of special interest not covered by existing courses. Format may consist of readings and independent study, problems or research not related to thesis. Also used to develop and test new 500-level courses. Graduate Staff

FOR 593 Colloquium on Tropical Forestry. *1(1-0) S.* Overview of tropical forest resources emphasizing biological, economic and social issues. Concepts and case studies covering ecological, silvicultural, cultural and socio-economic principles. Graduate Staff

FOR (FW) 594 Seminar in Wildlife Management. *1(1-0) S. Alt. yrs.* Current topics and issues in wildlife biology and management discussed. Students select and research topics, give seminars and lead group. Lancia

FOR GRADUATES ONLY

FOR 601 Advanced Hydrology. *Preqs.: FOR 401, ST 512. 3(3-0) S. Alt. yrs.* The physical concepts of water movement through the hydrologic cycle and interactions with ecosystem components discussed. Mathematical approaches to characterizing and quantifying hydrologic processes derived and applied to problem solutions. Experimental design and statistics needed for collecting and analyzing hydrologic data discussed and utilized. Development and use of simulation models considered. Gregory

FOR (GN) 611 Forest Genetics. *Preq.: GN 411 or CI. 3(3-0) S.* Application of genetic principles to silviculture, management and wood utilization. Emphasis is on variation in wild populations, the bases for selection of desirable qualities and fundamentals of controlled breeding. McKeand, Zobel

FOR (GN) 612 Advanced Topics in Quantitative Genetics. *Preqs.: GN (FOR) 611, GN (ST) 626 or GN (ANS) 603 or CI. 3(3-0) F. Alt. yrs.* Advanced topics in statistics and population genetics pertinent to current research problems in genetics with special applications to forestry. Basic statistical and genetic theory reviewed as bases for intensive study of selection theory and experimental and mating design evaluation. The genetics of natural populations studied for evolutionary interest as well as for their implications to breeding theory. Namkoong

FOR 613 Special Topics in Silviculture. *Preq.: FOR 304. 3(3-0) F.* Critical examination of selected silvicultural topics, with special emphasis on concepts and phenomena which distinguish forests from other biotic communities and silviculture from other fields of

applied biology. Emphasis on intensive silviculture in the United States and selected international locations. A written research proposal is a course requirement. Frederick

FOR 614 Advanced Topics in Administration of Forest Resources. *Preq.: FOR 613. 3(3-0) S.* State-of-the-art practices for administering commercial forest lands explicitly detailed for advanced forestry graduate students. The economics of intensive and extensive management, the effect of management policies on timber yields and the financial stability of the forest industry set forth using governmental and industrial perspectives.

Kellison, Lea

FOR 672 Current Issues in Natural Resource Policy. *2(2-0) S. Alt. yrs.* Discussion of the current and historical dimensions of major natural resource policy issues, including water and air pollution control, land use planning, public works development projects, wilderness, hazardous waste disposal and land preservation. Adams, Cooper, Devine

FOR(SSC) 673 Forest Productivity: Edaphic Relationships. *Preqs.: BO(ZO) 560, SSC 532. 3(2-3) S. Alt. yrs.* An advanced consideration of forest productivity; edaphic and other environmental factors influencing productivity; and the influence of forest management practices on forest soil properties and processes. Allen

FOR 689 Seminar in Forest Research. *Preq.: Grad. standing. 1(1-0) F.* Philosophy and objectives of scientific research and the steps in the research process. Basic and applied research, inductive and deductive reasoning and the need for hypothesis development and testing as a basis for scientific research. Special emphasis on the preparation of study plans, graduate theses, published articles and technical presentations. Franklin

FOR 691 Graduate Seminar. *1(1-0) F,S,Sum.* Weekly seminar in which students registered for the course present the results of research and special projects. All graduate students and faculty in the department invited to attend and join the discussion.

Graduate Staff

FOR 692 Advanced Topics in Forestry. *Credits Arranged. F,S,Sum.* Individual students or groups of students, under the direction of a faculty member, may explore topics of special interest not covered by existing courses. Format may consist of readings and independent study, problems or research not related to dissertation. Also used to develop and test new 600-level courses. Graduate Staff

FOR 699 Research in Forestry. *Credits Arranged. F,S,Sum.* Individual research, under faculty supervision, that will furnish material for a thesis or dissertation.

Graduate Staff

Genetics

GRADUATE FACULTY

Professor W. R. Atchley, Head

Professors: G. C. Bewley, W. D. Hanson, W. E. Kloos, C. S. Levings III, D. F. Matzinger, W. H. McKenzie, R. H. Moll, J. G. Scandalios, A. C. Triantaphyllou; *Professor (USDA):* C. W. Stuber; *Professor (USFS):* G. Namkoong; *Adjunct Professor:* M. D. Chilton; *Professors Emeriti:* C. H. Bostian, D. S. Grosch, T. J. Mann, L. E. Mettler; *Associate Professors:* S. E. Curtis, T. H. Emigh, T. F. C. Mackay, S. L. Spiker; *Assistant Professors:* M. T. Andrews, M. A. Conkling

ASSOCIATE MEMBERS OF THE DEPARTMENT

Professors: J. L. Apple, F. B. Armstrong, C. C. Cockerham, E. J. Eisen, M. M. Goodman, C. L. Markert, B. T. McDaniel, J. O. Rawlings, O. W. Robison, L. C. Saylor, H. E. Schaffer, R. R. Sederoff, W. F. Thompson, D. H. Timothy, B. S. Weir, E. A. Wernsman; *Professors Emeriti:* J. F. Chaplin, E. W. Glazener, F. L. Haynes, J. E. Legates, L. L. Phillips; *Associate Professors:* R. M. Petters, K. G. Tatchell; *Assistant Professors:* R. S. Boston, D. M. Miller

Graduate study under the direction of the genetics faculty may enable the student to qualify for the Master of Science or the Doctor of Philosophy degrees. A candidate for the master's degree must acquire a thorough understanding of genetics and its relation to other biological disciplines and must present a thesis based upon one's own research. In addition to a comprehensive knowledge of his or her field, a candidate for the doctorate must demonstrate a capacity for independent investigation and scholarship in genetics.

At North Carolina State University there are no sharp divisions along departmental lines or between theoretical and applied aspects of genetics research. The members and associate members of the genetics faculty are located in eight different departments of the Colleges of Agriculture and Life Sciences, Forest Resources and Physical and Mathematical Sciences. They are studying a wide range of genetic problems and are utilizing not only the "classic" laboratory materials (maize, bacteria, *Drosophila*, tobacco, mice), but also farm animals and agricultural and forest plants of the region. A student has, therefore, a wide choice of research problems in any of the following fields: cytology and cytogenetics, microbial and biochemical genetics, molecular and developmental genetics, evolution and speciation, quantitative and population genetics and the application of genetics to breeding methodology.

Departmental offices and laboratories are located in Gardner Hall with greenhouse facilities adjacent to the building. A genetics garden for use in intensive research with plants and teaching functions is located three miles from the offices. The departmental staff and the associate faculty members in animal science, biochemistry, botany, crop science, horticultural science, microbiology, plant pathology, statistics and the College of Forest Resources are fortunate in being able to draw upon the extensive facilities of the North Carolina Agricultural Research Service.

SELECTED ADVANCED UNDERGRADUATE COURSES

GN 411 The Principles of Genetics. *Preqs.: BS 100, jr. standing. 3(3-0) F,S,Sum.*

GN 412 Elementary Genetics Laboratory. *Preq. or coreq.: GN 411. 1(0-2) F,S.*

FOR GRADUATES AND ADVANCED UNDERGRADUATES

GN 504 Human Genetics. *Preq.: GN 301 or 411 or equivalent. 3(3-0) F.* The basic principles needed for an understanding of the genetics of man. Current knowledge and important areas of research in human genetics. McKenzie

GN 505A,B,C Genetics I. *Preq.: GN 411. 1-4 F.* Principles presented as a series of five-week minicourses: GN 505A, molecular genetics; GN 505B, biochemical genetics; GN 505C, developmental genetics. The laboratory, GN 505D, involves experimental techniques

in genetics and extends throughout the semester. Majors and minors must enroll for the entire course. Others may enroll for specific minicourses and attend the first lecture of semester for schedule. Graduate Staff

GN 506A,B,C Genetics II. *Preq.: GN 411; Coreq.: ST 511. 1-3 S.* Principles presented as a series of five-week minicourses: GN 506A, population genetics; GN 506B, quantitative genetics; GN 506C, cytogenetics. Majors and minors must enroll for the entire series. Others may enroll for specific minicourses and attend the first lecture of the semester for schedule. Graduate Staff

GN (ANS) 508 Genetics of Animal Improvement. *3(3-0) S.* (See animal science.)

GN (PO) 520 Poultry Breeding. *3(2-2) S.* (See poultry science.)

GN (ZO) 540 Evolution. *Preq.: Nine credits in biological sciences. 3(3-0) S.* The nature of organic evolution is explored by examining the types of evidence that allow reconstruction of the history of life on earth as well as experimental and descriptive evidence regarding the mechanisms of genetic change in populations. Graduate Staff

GN (CS, HS) 541 Plant Breeding Methods. *3(3-0) F.* (See crop science.)

GN (CS) 545 Origin and Evolution of Cultivated Plants. *3(3-0) S. Alt. yrs.* (See crop science.)

GN (BO, CS, HS) 547 Cell and Tissue Techniques in Plant Breeding. *3(1-4) F. Alt. yrs.* (See crop science.)

GN 555 Population Genetics. *Preqs.: GN 506A, MA 102. 3(3-0) S. Alt. yrs.* Theoretical population genetics and its relationship to natural and experimental populations. Topics include: single locus and multilocus systems, history of a gene in a population, diffusion approximations, suitability of models to natural and experimental populations. Emigh

GN (MB) 558 Prokaryotic Molecular Genetics. *3(3-0) S.* (See microbiology.)

GN 560 Molecular Genetics. *Preqs.: GN 411; BCH 451. 3(3-0) F.* A discussion of the structure and function of the genetic material at a molecular level. Both prokaryotic and eukaryotic systems considered. The aim will be to describe genetics in terms of chemical principles. Spiker

GN (BCH) 561 Biochemical and Microbial Genetics. *Preqs.: BCH 451 or 551, GN 411 or 505, MB 401 or equivalent. 3(3-0) F.* A study of the development of the fields of biochemical and microbial genetics, emphasizing both techniques and concepts currently used in molecular research. Includes lectures and discussions of current research publications. Armstrong

GN 567 Molecular Cytogenetics. *Preq.: GN 505 or equivalent. 3(3-0) F. Alt. yrs.* A molecular-genetic analysis of the structure function and evolution of eukaryotic genomes. Current methodology and approaches discussed, including DNA sequence analysis, chromosomal proteins, specific repeated genes, transposable elements in eukaryotic systems, structure and evolution of organelle genomes and use of recombinant DNA techniques in studies of chromosome structure. Graduate Staff

FOR GRADUATES ONLY

GN (ANS) 603 Population Genetics in Animal Improvement. *3(3-0) F.* (See animal science.)

GN (FOR) 611 Forest Genetics. *3(3-0) S.* (See forestry.)

GN (FOR) 612 Advanced Topics in Quantitative Genetics. 3(3-0) *F. Alt. yrs.* (See forestry.)

GN (CS, HS) 615 Quantitative Genetics in Plant Breeding. 1(1-0) *S. Alt. yrs.* (See crop science.)

GN (CS, HS) 616 Breeding Methods. 2(2-0) *S. Alt. yrs.* (See crop science.)

GN (CS, HS) 617 Nonconventional Plant Breeding. 1(1-0) *F. Alt. yrs.* (See crop science.)

GN (CS, HS, PP) 618 Breeding for Pest Resistance. 2(2-0) *F. Alt. yrs.* (See crop science.)

GN (ST) 626 Statistical Concepts in Genetics. 3(3-0) *S. Alt. yrs.* (See statistics.)

GN 641 Colloquium in Genetics. *Preqs.: Grad. standing; CI. 2(2-0) F,S.* Informal group discussion of prepared topics assigned by the instructor. Graduate Staff

GN 650 Developmental Genetics. *Preqs.: GN 505. 3(3-0) S. Alt. yrs.* The action and regulation of genes and gene-products in development and differentiation. Examples taken from microorganisms, plants and animals. Emphasis placed on molecular and biochemical aspects of mechanisms controlling gene expression in eukaryotic cell differentiation.

Curtis

GN 651 Somatic Cell Genetics. *Preqs.: GN 505; BCH 451. 3(3-0) S. Alt. yrs.* Discussion of the use of non-germ line cells for the genetic analysis of eukaryotic organisms. Plant, animal and fungal systems considered. Topics include: mutagenesis, selection, cell fusion, parasexual cycles, cloning, genetic engineering and regeneration of whole organisms.

Spiker

GN (BCH) 658 Nucleic Acids: Structure and Function. 3(3-0) *F. Alt. yrs.* (See biochemistry.)

GN (MB) 660 Experimental Microbial Genetics. 4(2-6) *S.* (See microbiology.)

GN 666 Laboratory in Molecular Genetics. *Preqs.: GN 505 or equivalent and CI. 4(2-6) S. Alt. yrs.* A laboratory course in modern techniques of molecular genetics for advanced students. Techniques include *in situ* hybridization, recombinant DNA methodology, and DNA sequencing. Enrollment limited to 12 students. Applications for a place in the course may be obtained from the instructor.

Conkling

GN 691 Seminar. *Preqs.: Grad. standing. 1(1-0) F,S.* Graduate Staff

GN 695 Special Problems in Genetics. *Preqs.: Advanced grad. standing, CI. 1-3 F,S.* Special topics designed for additional experience and research training. Graduate Staff

GN 699 Research. *Preqs.: Grad. standing, permission of adviser. Credits Arranged.* Original research related to the student's thesis problem. A maximum of six credits for the master's degree; by arrangement for the doctorate. Graduate Staff

Graduate School Registrations (GR)

For information regarding these registrations, see Special Registration and Fees.

History

GRADUATE FACULTY

Professor A. J. DeGrand, Head

Assistant Professor J. E. Crisp, Assistant Head

Professor W. C. Harris, Graduate Administrator

Professors: J. R. Banker, B. F. Beers, W. H. Beezley, C. H. Carlton, M. S. Downs, J. P. Hobbs, D. E. King, A. J. LaVopa, L. O. McMurry, J. M. Riddle, R. H. Sack, E. D. Sylla, B. W. Wishy; *Adjunct Professor:* R. L. Greaves; *Professors Emeriti:* M. L. Brown Jr., R. W. Greenlaw, M. E. Wheeler; *Associate Professors:* J. A. Mulholland, G. D. Newby, G. W. O'Brien, J. K. Ocko, S. T. Parker, R. W. Slatta, J. D. Smith, G. D. Surh, K. P. Vickery, K. S. Vincent; *Associate Professor Emeritus:* R. N. Elliott; *Assistant Professors:* D. P. Gilmartin, W. A. Jackson III, W. C. Kimler, K. P. Luria, S. L. Spencer; *Adjunct Assistant Professors:* W. S. Price Jr., H. K. Steen

ASSOCIATE MEMBER OF THE DEPARTMENT

Assistant Professor: J. C. Bonham

The history department offers programs leading to the Master of Arts degree in history and Master of Arts degree in archival management. Although no specific courses are stipulated for admission to the programs, preference will be given to those students with at least 18 hours in history and a total of 30 hours in the social sciences. Candidates are expected to have taken the aptitude portion of the Graduate Record Examination, or if admitted provisionally, must do so before the end of their first semester. Candidates are requested to include brief statements of their objectives in entering the programs along with their applications.

Normally a degree candidate for a Master of Arts in history will concentrate work in either European or American history with the required total of 30 hours being made up of nine to twelve hours of course work at the 500 level or above; six hours of research seminar (600 level); up to six hours of research and preparation of thesis (600 level); and six to nine hours of course work in a field related to the candidate's area of concentration (500 or 600 level). Under special circumstances a candidate may be permitted to include a 400-level course (see undergraduate catalog for descriptions) in his or her program if it has particular relevance to one's program objectives. Social studies teachers may be awarded G certification through completion of a degree with a major in history and a minor in education.

The Master of Arts in archival management requires thirty-six hours of courses, including two three-hour practicums in lieu of the thesis. Half of the course hours fall in historical studies, the rest in archival management. One practicum places the student under the direct supervision of the State Archivist of North Carolina. Students may select the other areas of interest—college

archives, history sites administration, museology, historical preservation or others.

One fellowship, one graduate scholarship and three teaching assistantships are now offered. Inquiry should be addressed to the graduate administrator.

North Carolina State University is a member of the Folger Institute of Renaissance and Eighteenth-Century Studies, a unique collaborative enterprise sponsored by the Folger Shakespeare Library in Washington, D.C., and twenty universities in the Middle Atlantic region. Each year the Institute offers an interdisciplinary program in the humanities—seminars, workshops, symposia, colloquia and lectures. Admission is open to faculty and students of North Carolina State University, and a limited number of fellowships are available through the Campus Folger Institute Committee.

FOR GRADUATES AND ADVANCED UNDERGRADUATES

NOTE: Prerequisite: (500 level) Six hours of advanced history or equivalent.

HI 509 The High Middle Ages. *Credit in both HI 409 and HI 509 is not allowed. 3(3-0).* An analysis of various aspects of medieval culture for the period 936-1250. Selected topics examined using source readings in such subjects as the revival of the Roman Empire, monastic and papal reform, the rise of universities, the evolution of representative bodies, the Gothic style, troubadour and goliardic poetry, scholasticism and the revival of Roman law.
Riddle

HI 515 Revolutionary Europe. *Credit in both HI 415 and HI 515 is not allowed. 3(3-0).* A broadly based analysis of Europe's first revolutionary era. Topics covered are the Enlightenment and its impact, the causes and character of the Revolution in France and the impact of these events in France and Europe.
Luria

HI 516 European Society and Culture in the Eighteenth Century. *Credit in both HI 419 and HI 519 is not allowed. 3(3-0).* Study of social traditions and change in Western Europe in the 18th century. Population growth and its effects, changes in lower and middle class family life, evolution of experience and perception of poverty, types of popular protest.
LaVopa

HI 518 Fascism in Germany and Italy, 1919-45. *Credit in both HI 418 and HI 518 is not allowed. 3(3-0).* Hitler and Mussolini: two aspects of European fascism.
DeGrand

HI 519 Modern European Imperialism. *Credit in both HI 419 and HI 519 is not allowed. 3(3-0).* Historical background of European Colonialism. Its influence on modern independence movements and major power foreign policy. Third World concept in international relations.
Gilmartin

HI 520 European Diplomatic History. *Credit in both HI 420 and HI 520 is not allowed. 3(3-0).* Survey of major issues and events in European international relations; Congress of Vienna, 1815, to defeat of Axis powers and origins of Cold War in 1945.
DeGrand

HI 525 Tudor and Stuart England. *Credit in both HI 425 and HI 525 is not allowed. 3(3-0).* British history from the Reformation to the Civil War. Primary emphasis on certain key developments in social, political and economic life, such as the development of a new concept of kingship, the growing independence of Parliament, the search for religious uniformity and the changing status of the aristocracy and gentry.
Graduate Staff

HI 528 England in the Age of the American Revolution. *3(3-0).* An intensive study of English political, religious, economic, social and imperial ideas and institutions between 1763 and 1783 with special emphasis on how these affected and were affected by the War of the American Revolution.
Downs

HI 539 The Russian Revolution. *Credit in both HI 439 and HI 539 is not allowed. 3(3-0).* The Russian Revolution as a connected episode, from the late Imperial period through the degeneration of Bolshevism under Stalin; the origins of revolutionary politics and the causes of the collapse of Tsarist autocracy; the dynamics of revolutionary events of 1917-1921; economic recovery and cultural pluralism of the 1920s; political repression and industrialization of the 1930s. Surh

HI 542 The United States: Revolution to Constitution. *Credit in both HI 442 and HI 542 is not allowed. 3(3-0).* The conflict with Great Britain after 1763 leading to the declaring of independence; the war for American independence; the political, social and ideological problems in establishing the government of the new nation. Graduate Staff

HI 546 Civil War and Reconstruction. *Credit in both HI 446 and HI 546 is not allowed. 3(3-0).* A study of the period of sectional strife, war and reconstruction, including a close examination of the sectional polarization of the 1850s, the impact of the war on both northern and southern societies and the trauma of reconstructing the Union. Harris

HI 554 History of U. S. Foreign Relations, 1900-Present. *Credit in both HI 454 and HI 554 is not allowed. 3(3-0).* American diplomatic history since 1900; the expansion of American economic and cultural relations; the evolution of the American foreign policy bureaucracy; and the historical forces and personalities that shaped American relations with other nations. Beers

HI 555 History of the Civil Rights Movement. *Preqs.: 6 hrs. of advanced HI; jr. standing. 3(3-0).* *Credit for both HI 455 and HI 555 is not allowed.* The "black revolution;" stages and leaders of the movement; successes and failures in the fight for desegregation, the vote and economic opportunity; impact of Civil Rights movement on the United States.

Graduate Staff

HI 556 American Heritage. *Credit in both HI 456 and HI 556 is not allowed. 3(3-0).* Development of American ideals since colonial times studied through the words of famous Americans and in the context of events like the American Revolution and the Great Depression. Stress on the conflicts, during important crises, between freedom and order, liberty and equality, free enterprise and social justice, religious truth and workaday morality, the nation and the world. Graduate Staff

HI 561 Civilization of the Old South. *Credit in both HI 461 and HI 561 is not allowed. 3(3-0).* The distinctive features of the Old South as part of the regional development of the United States. Colonial factors in the making of the South, development of the plantation system and slavery, Southern social order, intellectual and cultural life, economic development and rise of Southern nationalism. Crisp, Smith

HI 562 Social History of the New South. *Credit in both HI 462 and HI 562 is not allowed. 3(3-0).* Analysis of southern society from the Civil War through the present, with an emphasis on social history methods, approaches and sources. Graduate Staff

HI 565 The History of Urban Life in the U.S., 1607-1865. *Credit in both HI 465 and HI 565 is not allowed. 3(3-0).* The historical background of today's urban problems. King

HI 566 The History of Urban Life in the U.S., 1865-Present. *Credit in both HI 466 and HI 566 is not allowed. 3(3-0).* The historical background of today's urban problems. King

HI 569 Latin American Revolutions in the Twentieth Century. *Credit in both HI 469 and HI 569 is not allowed. 3(3-0).* The varieties of revolutionary changes in twentieth-century Latin American revolutions: Argentina, Bolivia, Peru, Cuba and Chile. Beezley, Slatta

HI 576 Leadership in Modern Africa. *Credit in both HI 476 and HI 576 is not allowed. 3(3-0).* The conditions under which 20th century African leaders have obtained and exercised power. Case studies of prominent leaders, both radicals, reactionaries, democrats and tyrants, such as Nkrumah, Kenyatta, Nyerere, Amin, Cabral, Vorster and Senghor. Vickery

HI 580 Scientific Revolution: 1300-1700. *Credit in both HI 480 and HI 580 is not allowed. 3(3-0).* Factors behind dramatic scientific changes of the seventeenth century. Role of mathematics and experiment. Interaction of the new science with trends in philosophy, religion, alchemy, magic, medicine and with institutional educational, political, economic and technological factors. Sylla

HI 581 History of Life Sciences. *Credit in both HI 481 and HI 581 is not allowed. 3(3-0).* Surveys the major ideas, methods, institutions and individuals that have contributed to the biological sciences from antiquity to modern times and examines the connections between the life sciences and other aspects of culture, including the physical sciences, religious belief, medical practice and agriculture. Students in the History of Life Sciences read original sources and historical monographs concerning those topics. Kimler

HI 582 Darwinism in Science and Society. *Preqs.: 6 hrs. of advanced HI; jr. standing. 3(3-0). Credit for both HI 482 and HI 582 is not allowed.* Darwinism and its reception by the scientific community and the general public. Social impact of theories of evolution as expected in social Darwinism, eugenics, sociobiology and the relationship of science to ethics and religion. Graduate Staff

HI 585 Principles and Practice of Applied History. *Preqs.: Grad. standing; 6 hours of history or equivalent. Credit in both HI 485 and HI 585 is not allowed. 3(3-0).* An introduction to applications of history to public life and to the conservation and presentation of historical materials, with particular attention to conservation problems generated by modern technology. Topics include archives, records management, historical editing, museology, historical preservation, special forms of presentation like historic sites and audiovisual techniques and computer applications. Smith

HI 586 History and Principles of the Administration of Archives and Manuscripts. *Credit in both HI 486 and HI 586 is not allowed. 3(3-0).* Nature, importance and use of original manuscript resources; the history and evolution of written records and the institutions administering them; the principles and practices of archives administration. Olson

HI 587 Application of Principles of Administration of Archives and Manuscripts. *Preqs.: Six hours of advanced history and HI 586. Credit in both HI 487 and HI 587 is not allowed. 3(3-0).* Internship training in the application of the principles and practices of archival management as developed in HI 586. Olson

FOR GRADUATES ONLY

NOTE: Prerequisite: (600 level) Six hours of advanced history or equivalent.

HI 601 Historiography and Historical Method. *3(3-0).* A study of the major steps in the development of historical investigation; analysis of elements of historical research; discussion of methodology and archival materials used by the contemporary scholarly historian. Graduate Staff

HI 602 Historical Writing. *Preq.: Grad. standing or PBS status. 3(3-0).* Critical studies in the methods and practice of contemporary historical writing. Graduate Staff

HI 685 Independent Study. *Preq.: Grad. standing or PBS status. 1-6.* Individualized study conducted under supervision of graduate faculty. Letter grades (ABCD/NC). Course of study, assigned readings, course projects or papers, and methods of evaluating work to be detailed in writing and approved by department head. Graduate Staff

HI 688 Iconographic and Other Archival Materials. *Preq.: HI 485/585. 3(2-2).* Introduction to archival materials. Examination of and practice in the storage and care of paper and books, prints, engravings and maps. Films, transparencies, negatives, magnetic tapes and phonorecords. Emphasis on preventive conservation. Mulholland, Smith

HI 689 Documentary Editing. *Preq.: HI 485/585. 3(3-0).* An introduction to the field of documentary editing. Development of historical editing and the rules of literal, expanded and modern editorial method. Special documentary/papers projects. Crow, Smith

HI 691 Practicum in Applied History. *Preq.: HI 601, 602, 685. 1-6.* Supervised internship experience in an archival management and/or applied history. Graduate Staff

HI 699 Research in History. *Credits Arranged. 1-6.* Individual research under graduate thesis supervisor. Graduate Staff

Horticultural Science

GRADUATE FACULTY

Professor T. J. Monaco, Head

Professor D. J. Werner, Graduate Administrator

Professors: J. R. Ballington, F. A. Blazich, W. W. Collins, A. A. DeHertogh, R. A. Larson, J. W. Love, C. M. Mainland, C. H. Miller, P. V. Nelson, D. M. Pharr, J. C. Raulston, D. C. Sanders, W. A. Skroch, C. R. Unrath, T. C. Wehner, L. G. Wilson, E. Young; *Professors Emeriti:* W. E. Ballinger, F. D. Cochran, F. L. Haynes, J. M. Jenkins, T. R. Konsler, D. T. Pope; *Associate Professors:* T. E. Bilderback, S. M. Blankenship, P. R. Fantz, W. C. Fonteno III, R. G. Gardner, W. R. Henderson, L. E. Hinesley, W. E. Hooker, M. M. Peet, K. B. Perry, E. B. Poling; *Adjunct Associate Professor:* P. S. Zorner; *Associate Professors Emeriti:* T. F. Cannon, D. C. Zeiger; *Assistant Professors:* J. M. Davis, R. G. Goldy, S. L. Warren, *Lecturer:* M. E. E. Traer

ASSOCIATE MEMBERS OF THE DEPARTMENT

Professors: D. E. Carroll Jr., R. J. Downs, R. H. Moll, R. L. Mott, T. J. Sheets;
Professor Emeritus: R. Aycock

Graduate study under the direction of the horticultural science faculty may lead to the Master of Science and the Doctor of Philosophy degrees. Areas of study include plant physiology, plant breeding and genetics, post-harvest physiology, agricultural meteorology, plant nutrition, tissue culture, growth regulators and weed science. The Master of Agriculture, a professional degree, can be earned by substituting additional course work for research requirements of graduate study.

Facilities for graduate studies on the Raleigh campus include a 30,000 square-foot greenhouse (21 sections, each with separately controlled light and temperature); the University Phytotron (available for controlled environmental studies on horticultural crops); 19 well-equipped laboratories (chromatography, seed handling and storage, cytological/anatomical, radioisotope, tissue culture, post-harvest and nutritional studies). There are 14 controlled temperature storage rooms; an extensive collection of plant materials, both living (NCSU Arboretum) and preserved; and a variety of climates and soils from coast to mountains in North Carolina on 15 outlying research stations.

Opportunities for employment after graduate study include: teaching and research faculty positions in state and private universities; research and regulatory positions with the Departments of Agriculture, both foreign and domestic; extension specialists and county agents; research, production and promotional work with agri-business concerned with production of horticultural crops or services to horticultural industries.

Graduate teaching and research assistantships (commercial, Agricultural Foundation or N.C. Agricultural Research Service) for promising and qualified students are available. Students are encouraged to apply for assistantships at least six months prior to the anticipated enrollment date.

SELECTED ADVANCED UNDERGRADUATE COURSES

HS 400 Residential Landscaping. *Preqs.: DF 234; HS 211, 212, 342; HS 416 or DN 433; SSC 200, DN 257, 430. Seniors in the landscape area of concentration given priority. 6(0-9) F,S.*

HS 411 Nursery Management. *Preqs.: BS 100, SSC 200, jr. standing. 3(2-3) F.*

HS 416 Principles of Ornamental Planting Design. *Preqs.: HS 211, HS 212, HS 342, SSC 200, DN 234. 3(2-4) F,S.*

HS 421 Tree Fruit Production. *Preqs.: BS 100 or BO 200, SSC 200, HS 201. 3(2-3) F.*

HS 422 Small Fruit Production. *Preqs.: BS 100 or BO 200, SSC 200, HS 201. 3(2-3) S. Alt. yrs.*

HS 431 Vegetable Production. *Preqs.: BS 100, SSC 200. 4(3-3) F.*

HS 440 Greenhouse Management. *Preqs.: BS 100, SSC 200. 3(2-3) F.*

HS 441 Floriculture I. *Preqs.: BS 100, SSC 200. 3(2-3) F.*

HS 442 Floriculture II. *Preqs.: BS 100, SSC 200. 3(2-3) S.*

HS 471 Tree and Grounds Maintenance. *Preqs.: BS 100 or BO 200; PP 315; SSC 200. 4(3-3) S.*

HS 491 Horticultural Science Seminar. *Preq.: Jr. standing in horticultural science. 1(1-0) F.*

HS 495 Special Topics in Horticultural Science. *1-6 F,S.*

FOR GRADUATES AND ADVANCED UNDERGRADUATES

HS(CS)515 Weed Science Research Techniques. *Preq.: CS 414 or equivalent. 1(0-2) F.* Bioassay techniques for detection of herbicide residues in soils, chemical analytical (GLC, HPLC) techniques for identifying herbicide residues in soils and plants, procedures for studying adsorption and leaching in soils, procedures for measuring herbicide interference of photosynthesis and use of ^{14}C -labeled herbicides for following uptake, transport and metabolism of herbicides in plants. Graduate Staff

HS(CS)516 Weed Biology. *Preq.: CS 414. 1(1-0) F.* Weed seed development and dispersal, seed dormancy, soil seed bank, seedling development, growth analysis, reproduction, community structure, population dynamics, species interactions, environmental effects on interactions and influence of man. Taught first 5 weeks of semester. Graduate Staff

HS (CS) 517 Weed Management Systems. *Preq.: CS 414 or equivalent. 1(1-0) F.* Weed management systems including integration of cultural, biological, mechanical and chemical methods for vegetables, fruits, ornamentals, turf, small grains, corn, tobacco, cotton, peanuts, aquatic and non-cropland settings. Taught second 5 weeks of semester.

Graduate Staff

HS (CS) 518 Biological Control of Weeds. *Preq.: CS 414 or equivalent. 1(1-0) F.* Concepts and methods in the use of biological agents for control of weeds. Primary emphasis on weed biocontrol with insects and plant pathogens. Taught third 5 weeks of semester.

Graduate Staff

HS 531 Physiology of Landscape Plants. *Preq.: BO 421 or CI. 3(2-3) S.* A course designed to cover relationships of plants to landscape environments. Study of plant function, basic climatology and plant physiological principles involved in the selection, utilization and maintenance of physical landscape environments in exterior and interior ornamental landscape plantings.

Raulston

HS 532 Vegetable Crop Physiology. *Preqs.: BO 421, HS 431, SSC 341. 2(2-0) F. Alt. yrs.* Physiological aspects of field and greenhouse vegetable production: germination, photo-period, nutrition, growth regulations, fruit quality, physiological disorders, source-sink interactions, environmental physiology and physiological aspects of plant protection. Emphasis on current areas of research and the physiological implications of new production techniques.

Peet

HS 534 Vegetable Crops Practicum. *Preq.: HS 431. 3(1-6) S. Alt. yrs.* Field techniques for research on vegetable production problems. Eleven all-day field trips (two overnight) required during the period May-August.

Peet

HS (CS, GN) 541 Plant Breeding Methods. *3(3-0) F.* (See crop science.)

HS (BO, CS, GN) 547 Cell and Tissue Techniques in Plant Breeding. *3(1-4) F. Alt. yrs.* (See crop science.)

HS (FS) 562 Postharvest Physiology. *Preq.: BO 421. 3(3-0) S.* A study of chemical and physiological changes that occur during handling, transportation and storage which affect the quality of horticultural crops. Consideration given to preharvest and postharvest conditions which influence these changes.

Blankenship

HS 595 Special Topics in Horticultural Science. *Preq.: CI. 1-6 F,S,Sum.* Investigation of special theoretical problems at the 500 level in horticultural science not related to a thesis problem; new 500-level courses during the developmental phase.

Graduate Staff

HS 599 Research Principles. *Preq.: CI. Credits Arranged, Maximum 6.* Investigation of a problem in horticulture under the direction of the instructor. The students obtain practice in experimental techniques and procedures, critical review of literature and scientific writing. The problem may last one or two semesters. Credits determined by the nature of the problem, not to exceed a total of three hours for any one problem. A written report and final oral exam required for completion of course.

Graduate Staff

FOR GRADUATES ONLY

HS 601 Carbohydrate Metabolism and Transport. *Preq.: BO 421. 1(1-0) F.* Historical and current research related to the regulation of aspects of carbohydrate metabolism important to plant growth, yield and quality. Taught first five weeks of semester.

Graduate Staff

HS 602 Environmental Stress Physiology. *Preq.: BO 421. 1(1-0) F.* Nature of environmental stresses which plants encounter such as chilling, freeze, heat, drought, excess water, salt, ion and radiation, and physiology of plant responses and resistance mechanisms. Taught second five weeks of semester.

Graduate Staff

HS 603 Breeding Asexually Propagated Crops. *Preq.: CS 413. 1(1-0) F.* Principles and problems associated with breeding clonally propagated crops and the techniques used in overcoming these problems. Taught third five weeks of semester. Graduate Staff

HS 604 Plant Nomenclature. *Preq.: BO 421. 1(1-0) S.* A practical foundation in plant nomenclature and nomenclatural references. Emphasis on the evolution of the international rules for naming plant taxa and their application to both wild and cultivated plants. Nomenclatural applications used in patents, cultivar releases and journal articles. Taught first five weeks of semester. Graduate Staff

HS 605 Physiology of Flowering. *Preq.: BO 421. 1(1-0) S.* Examination of the physiological basis of flowering in plants such as: floral initiation, transition to reproductive growth; floral development; plant response to light, temperature, nutrition, water supply; plant age; chemical growth regulation and *in vitro* flowering. Taught second five weeks of semester. Graduate Staff

HS 606 Fruit Development and Postharvest Physiology. *Preq.: BO 421. 1(1-0) S.* Theories of plant senescence, both physiological and biochemical, and postharvest changes in all types of plant parts. Emphasis on the physiological principles which underlie current postharvest handling and storage techniques. Includes a study of fruit development from fruit set to senescence. Taught third five weeks of semester. Graduate Staff

HS (CS, SSC) 614 Herbicide Behavior in Plants and Soils. *3(3-0) F.* (See crop science.)

HS (CS, GN) 615 Quantitative Genetics in Plant Breeding. *1(1-0) S. Alt. yrs.* (See crop science.)

HS (CS, GN) 616 Breeding Methods. *2(2-0) S. Alt. yrs.* (See crop science.)

HS (CS, GN) 617 Nonconventional Plant Breeding. *1(1-0) F. Alt. yrs.* (See crop science.)

HS (CS, GN, PP) 618 Breeding for Pest Resistance. *2(2-0) F. Alt. yrs.* (See crop science.)

HS 621 Methods and Evaluation of Horticultural Research. *Preq.: Grad. standing. 3(3-0) F.* Study of necessary elements for a career in horticultural research including: background and philosophy of scientific research; survey of horticultural research history and current status; research design and evaluation; photographic techniques; technical writing including project proposals, administrative reports and publications; office and personnel management. Raulston

HS 622 Mineral Nutrition in Plants. *Preqs.: BO 551, 552. 3(2-3) S. Alt. yrs.* A comprehensive study of the functional roles of nutrients essential to plant growth, their interrelationships and their mode of influence on quality indices of crops. Consideration of the complexity of mineral nutrition experimentation and evaluation of results. A detailed look at the establishment and application of foliar analysis, foliar fertilization and slow-release fertilizers. A general view of the nutrient uptake process in plants. Nelson

HS 691 Seminar. *Preq.: Grad. standing. 1(1-0) F,S.* Required of all graduate students with a minor in horticultural science. Optional for all horticultural science graduate students. Presentation of scientific articles and special lectures. Students required to present one or more papers. Graduate Staff

HS 695 Graduate Topics in Horticultural Science. *Preq.: CI. 1-6 F,S,Sum.* Investigation of theoretical problems at the 600 level in horticultural science not related to a thesis problem; new 600-level courses during the development phase. Graduate Staff

HS 699 Research. *Preqs.: Grad. standing in HS, consent of advisory committee chairman. Credits Arranged.* A maximum of six credits is allowed toward the Master of Science degree; no limitation on credits in doctoral program. Original research on specific problems in fruit, vegetable and ornamental crops. Graduate Staff

Industrial and Technical Education

For a listing of graduate faculty and program information, see industrial and technical education in the education section.

Industrial Arts Education

For a listing of graduate faculty and program information, see industrial arts education in the education section.

Industrial Engineering

GRADUATE FACULTY

Professor T. J. Hodgson, *Head*

Professor R. G. Pearson, *Graduate Administrator*

Professors: M. A. Ayoub, R. H. Bernhard, J. R. Canada, S. E. Elmaghraby, S.-C. Fang, H. L. W. Nuttle, A. L. Prak, W. A. Smith Jr.; *Professors Emeriti:* R. E. Alvarez, C. A. Anderson, R. W. Llewellyn; *Associate Professors:* P. J. O'Grady, R. E. Young; *Adjunct Associate Professors:* D. C. Antonelli, M. G. Joost; *Associate Professor Emeritus:* J. J. Harder; *Assistant Professors:* D. W. Aldrich, J. F. Antin, D. P. Bischak, C. T. Culbreth Jr., Y. Fathi, R. E. King, E. T. Sanii; *Visiting Assistant Professor:* J. Trevino; *Adjunct Assistant Professors:* B. H. Beith, C. B. Oldham, J. Taheri

ASSOCIATE MEMBERS OF THE DEPARTMENT

Associate Professors: W. J. Rasdorf, R. D. Rodman; *Assistant Professor:* N. M. Bengtson

Industrial engineering is concerned with solutions to problems relating to design and control of organizational systems, such as industrial and commercial corporations, government agencies, and other institutions which provide goods or services for public consumption. Interests include the management of operations, planning and scheduling, manufacturing engineering, allocation of resources, dynamic system design, man-machine relationships, and occupational safety and health.

The department offers the degrees of Master of Science and Doctor of Philosophy. Principal areas of specialization include manufacturing systems, production systems, information systems, economic decision analysis, and ergonomics.

Typical minors are taken in statistics, economics and business, computer science, artificial intelligence, psychology, operations research, and other engineering disciplines.

The M.S. degree may be taken either with or without a thesis. The thesis work for the M.S. degree may account for as many as six semester hours. For the non-thesis option a formal written report, based upon scholarly project work, is required. A departmental brochure which details the orientation and requirements for all degrees is available. No foreign language is required at the master's level, and a foreign language is optional with the student's advisory committee at the doctoral level.

The University provides access to an outstanding mainframe computer facility at the Triangle Universities Computing Center (TUCC) through conveniently located computer terminals. In addition, the department supports a VAX 11/750 and a MICROVAX II, both of which are networked campus and nationwide. Other resources include a wide range of microcomputer systems, among which are several INTEL 310 supermicrocomputers and Tektronics graphic terminals. The manufacturing laboratory has a representative sample of basic machine tools and numerical control equipment. A number of robots exist for part handling and assembly work research. Modern material handling equipment, such as computer-controlled carousels and conveyors, and a broad range of programmable controllers are part of the manufacturing cells for research in decision support systems for flexible assembly operations and robotics issues. Facilities for ergonomics research are also excellent for the study of environmental factors, biomechanics, work physiology and human performance assessment.

SELECTED ADVANCED UNDERGRADUATE COURSES

IE 401 Stochastic Models in Industrial Engineering. *Preq.: An introductory course in probability and/or math statistics. 3(3-0) F,S.*

IE (CSC) 441 Introduction to Simulation. *Preqs.: MA 202, ST 372, proficiency in a programming language 3(3-0) F,S.*

IE 443 Quality Control. *Preq.: ST 361. 3(2-2) F,S,Sum.*

IE 452 Ergonomics. *Coreq.: IE 352. 3(2-2) F,S.*

IE 453 Facilities Design. *Preqs.: IE 351, 352. 3(2-2) F.*

FOR GRADUATES AND ADVANCED UNDERGRADUATES

IE (MA, OR) 505 Linear Programming. *Preq.: MA 405. 3(3-0) F,S.* A study of mathematical methods applied to problems of planning. Linear programming covered in detail. This course intended for those who desire to study this subject in depth and detail. It provides a rigorous and complete development of the theoretical and computational aspects of this technique as well as a discussion of a number of applications. Fathi, Peterson

IE (OR) 509 Dynamic Programming. *Preqs.: MA 405, ST 421. 3(3-0) S.* An introduction to the theory and computational aspects of dynamic programming and its application to sequential decision problems. Elmaghraby

IE 511 Capital Investment Economic Analysis. *Preqs.: IE 311, ST 371. 3(3-0) F.* Analysis of economic merits of alternatives including interest and income tax considerations.

Risk and sensitivity exploration techniques. Introduction to analytical techniques for multiple objectives or criteria. Use of mathematical programming and computers for capital budgeting. Bernhard, Canada

IE 512 Bayesian Decision Analysis for Engineers and Managers. *Preqs.: ST 371 or ST 421. 3(3-0) F.* The Bayesian approach to decision making, with numerous applications in engineering and business. Expected value maximization, decision trees, Bayes' theorem, value of information, sequential procedures and optimal strategies. Axiomatic utility theory and controversies, utility of money, theoretical and empirical determination of utility functions and relationship to mean-variance analysis. Brief introduction to multi-attribute problems, time streams and group decisions. Bernhard, Canada

IE 515 Advanced Manufacturing Processes. *Preqs.: IE 351 and ECE 331 or equivalent. 3(3-0) F.* The course examines manufacturing processes which involve chemical, electrochemical, electrical, thermo-electric and non-conventional mechanical energy modes. Each process investigated as to its underlying theory, state-of-the-art technology, interaction with the workpiece material, geometric capability and economics. O'Grady, Sanii

IE 516 CAM I: A Systemic Approach to Computer-Aided Manufacturing. *Preq.: IE 351. 3(3-0) F.* General principles of CAD/CAM integration. Elements of computer graphics. Engineering data base. Computer Process Control. Group Technology concepts and applications. Flexible manufacturing systems. Culbreth, O'Grady, Sanii

IE 517 CAM II: Software Applications in Computer-Aided Manufacturing. *Preqs.: IE 516. 3(3-0) S.* Computer techniques for controlling machine tool motions. Extensive application of Numerical Control Programming using the APT language. Computer Aided Process Planning through the CAPP system. Theory and applications of Programmable Controllers for Process Control. Various application software for manufacturing use. O'Grady, Sanii

IE 518 Manufacturing Operations Management. *Preqs.: MA 202 or MA 212; ST (EB) 350 or ST 372. 3(3-0) F. Not for IE majors.* Concepts, problems and procedures for the management of manufacturing operations. Emphasis on forecasting, capacity planning, material requirements planning, scheduling, inventory control and related computer-based control systems. Hodgson, King, Nuttle

IE (MAE) 520 Industrial Robotics. *Preqs.: IE 351; MA 301 or MA 303. 3(3-0) F.* Development, structure, specifications and capabilities of industrial robots. Robot control fundamentals. Kinematics of manipulators. Applications, selection, economics and implementation of robotic systems. Safety considerations, end-of-arm tooling and design of robotic workplace. Actuators, sensors including vision and tactile sensory systems for robots. Sanii

IE 521 Management Decision and Control Systems. *Preqs.: IE 421, CSC 421 or equivalent. 3(3-0) S.* Planning and development of comprehensive computer-based information systems to support management decisions. Formal systems concepts; management information requirements. Management science and organizational behavior influences. Data bases and advanced system techniques and concepts. System evaluation and cost effectiveness. Smith

IE 523 Production Planning, Scheduling and Inventory Control. *Preqs.: OR 501 and ST 515 or equivalents. 3(3-0) S.* An analysis of Production-Inventory systems. Discussion of commonly used planning and scheduling techniques. Introduction to the use of math modeling for solution of planning and scheduling problems. Interface with quality control and information systems. Hodgson, King, Nuttle

IE 525 Organizational Planning and Control. *Preq.: Three hrs. in operations management (such as EB 325, IE 308). 3(3-0) F.* Organization theory and systems approaches to administrative functions. Human and social influences of management systems for plan-

ning and control of activity. Policy, structure and procedure related to industrial engineering activities. Effects of automation. Smith

IE (PSY) 540 Human Factors in Systems Design. *Preq.: IE 452 or PSY 340; Coreq.: ST 507 or 515. 3(3-0) F.* Introduction to the systems development cycle, Man-machine function allocation, design standards, display and control systems, workspace layout, the personnel sub-system concept, anthropometry and maintainability design. Antin, Pearson

IE 541 Systems Safety Engineering. *Preqs.: IE 452, ST 371. 3(3-0) S.* Problems in occupational safety and health; OSHA standards; preventive aspects involving product and work design and personnel selection. Consideration of the methods used in accident-injury study, including field investigation, experimental engineering and biomedical research, and statistical and epidemiological studies. Managerial aspects of safety accountability. Product liability and forensics. Pearson

IE 542 Physiological Criteria in Work Measurement. *Preq.: Grad. status. 3(3-0) F. Alt. yrs.* Emphasis placed on basic endocrine and autonomic nervous system anatomy and physiology; measures reflecting sympathetic nervous system activity; concepts applicable to work measurement studies including a discussion of arousal theory and the concept of autonomic balance; and survey of current literature on equipment design and use. Ayoub

IE 544 Occupational Biomechanics. *Preq.: Grad. standing in engineering. 3(2-2) F. Alt. yrs.* General concepts and techniques of understanding the anatomical and physiological bases of human motion. Characteristics and limitations of human motor capabilities, body mechanics and use of biomedical instrumentation for monitoring and quantifying human performance. Applications of biomechanics in work, industry, rehabilitation, sports, space research and safety are also considered. Ayoub

IE (PSY) 545 Human Performance. *Preqs.: Grad. standing; ST 507 or equivalent. 3(3-0) S. Alt. yrs.* Fundamentals of human perceptual and motor abilities basic to skilled operator performance. Theoretical models of man as an operator. The human as an information processing mechanism. Motor skills learning, performance decrement and information feedback. Channel capacity, stress, fatigue, arousal theory. Attention, time-sharing and workload. Sustained performance, vigilance, monitoring, search, inspection and tracking. Circadian rhythms; sleep loss; shiftwork. Pearson

IE 547 Reliability Engineering. *Preq.: ST 515 or equivalent. 3(3-0) F. Alt. yrs.* An introduction to basic concepts of reliability engineering. Includes application of probability and statistics to estimate reliability of industrial systems; development of reliability measures; analysis of static and dynamic reliability models; development and analysis of fault trees; analysis of Markovian and non-Markovian models; and optimization of reliability models. Fathi, King

IE 548 Quality Engineering. *Preqs.: OR 501, ST 515. 3(3-0) F. Alt. yrs.* An introduction to basic concepts of quality engineering. Topics include statistical process control (SPC) methods, acceptance sampling techniques, concept of parameter design and statistical as well as analytical techniques for its implementation, tolerance analysis and design, components of cost of poor quality and an introduction to quality management. Fathi

IE 553 Material Handling Systems. *Preq.: IE 453. 3(3-0) S.* Analysis, design, evaluation and implementation of material handling systems. Principles, functions, equipment concepts and traditional approaches of material handling. Impact of facilities design on material handling and application of quantitative techniques to material handling systems design. Description of factors and approaches to material handling management and the criticality of properly designed and operated material flow systems. Trevino

IE 556 Industrial Logistics. *Preq.: IE 453. 3(3-0) F.* Materials management, materials flow and physical distribution. Management of activities required to move raw materials, parts and finished inventory from vendors, within an enterprise and to customers. This course covers the design and operation of effective industrial logistics systems. Trevino

IE (OR) 561 Queues and Stochastic Service Systems. *Preq.: MA 421. 3(3-0) F.* General concepts of stochastic processes introduced. Poisson processes, Markov processes and renewal theory presented. These then used in the analysis of queues, starting with a completely memoryless queue to one with general parameters. Applications to many engineering problems considered.
King, Perros, Stewart

IE (CSC, ECE, OR) 562 Computer Simulation Techniques. *3(3-0) F.* (See computer studies.)

IE (CSC, ECE) 575 Voice Input/Output Communication Systems. *Preqs.: MA 202 and IE 307 or CSC 312. 3(3-0) F.* Introduction to the physical, linguistic and computational principles that underlie speech synthesis and speech recognition. Human factors of speech I/O. Advantages and disadvantages of implementing voice applications. Hands-on use of voice I/O equipment through class projects. Case studies of current applications of speech I/O technology.
Rodman

IE (MA, OR) 586 Network Flows. *Preq.: IE (OR, MA) 505 or equivalent. 3(2-2) S. Alt. yrs.* This course studies problems of flows in networks. These problems include the determination of the shortest chain, maximal flow and minimal cost flow in networks. The relationship between network flows and linear programming developed as well as problems with nonlinear cost functions, multicommodity flows and the problem of network synthesis.
Elmaghraby, Fathi

IE 589 Special Topics in Industrial Engineering. *Preqs.: Grad. or sr. standing and CI. 1-4.* Exploration of emerging topics of interest to faculty and students. Generally used for the first offering of a new course, using conventional lecture format. Sometimes used for directed readings, problem sets and reports as required.
Graduate Staff

IE 591 Project Work. *Preq.: Grad. standing. 1-6 F,S,Sum.* Investigation and report on assigned problems requiring application of industrial engineering techniques.
Graduate Staff

IE (PSY) 593 Area Seminar in Ergonomics. *1(0-2) F.* (See psychology.)

FOR GRADUATES ONLY

IE 611 The Design of Production Systems. *Preqs.: IE 523, OR 501. 3(3-0) F. Alt. yrs.* The structure and operation of production planning, scheduling and control systems; emphasis on system structure, capacity planning, master production scheduling and shop loading; investigation of current trends in the field.
Elmaghraby

IE 616 Computer Integration of Manufacturing Systems. *Preqs.: IE 516, IE 517. 3(3-0) F.* In-depth study of computer integration of manufacturing systems. CIM elements (CAD, CAPP, CNC, industrial robotics), manufacturing control, communication and networking, interfacing, database design, material handling and computer hardware requirements in automated manufacturing systems. Emphasis on the integration of the components involved in computerized manufacturing environments.
Culbreth, O'Grady, Sanii

IE 621 Advanced Problems in Management Systems Engineering. *Preq.: CI. 1-4 S.* Coverage of advanced techniques, current research and contemporary problems in analysis, design and operation of management systems. Varied topics cover aspects of economic decision analysis, cost effectiveness, information flow, system performance evaluation and modern organization concepts.
Bernhard, Canada, Smith

IE 622 Inventory Control Methods II. *Preq.: IE 523. 3(3-0) F.* A continuation of IE 523; stochastic inventory systems of lot sized-reorder type; periodic review and single period models. Application of dynamic programming theory to deterministic and stochastic cases.
Hodgson, King, Nuttle

IE 631 Multi-attribute Decision Analysis. *Preqs.: IE 511 or IE 512; OR 501 or OR 505. 3(3-0) S.* Specification of attributes/criteria/objectives for complex decisions. Determination of alternatives, attribute weights and decision-making process. Graphical and weighted evaluation techniques. Multi-attribute utility, multi-objective/goal programming and analytic hierarchy process methodologies. Computer applications and case studies.

Canada

IE (PSY) 640 Skilled Operator Performance. *Preqs.: PSY 545, ST 507, or ST 515. 3(3-0) S. Alt. yrs.* Theories of the human operators are considered with regard to the classical problems of monitoring, vigilance and tracking. Factors such as biological rhythm, sleep loss, sensory restriction, environmental stress and time-sharing considered as they interact with and determine overall systems efficiency.

Antin, Pearson

IE 641 Environmental Factors and Human Performance. *Preqs.: IE (PSY) 540 and IE 542 or other equivalent. 3(3-0) S. Alt. yrs.* Study of major problem areas, methodology, theory and experimental work in biotechnology; interaction among engineering, biological and behavioral factors in design for safety and survival; physiology and biomechanics of acceleration, deceleration and pressure altitude; consideration of operator effectiveness in submarine, extra-terrestrial, arctic and desert environments; techniques in evaluation of crash dynamics and pathology; closed-ecological systems.

Pearson

IE 646 Human Factors in Visual Display Systems. *Preq.: IE (PSY) 540. 3(3-0) S. Alt. yrs.* Electronic visual display systems; integration of photometry, vision and image quality metrics with human factors design concepts associated with standard and advanced display technology options (e.g., CRT, flat panels and virtual image displays); applications and research issues.

Graduate Staff

IE 651 Special Studies in Industrial Engineering. *Preq.: Grad. standing. Credits Arranged.* The purpose of this course is to allow individual students or small groups of students to undertake studies of special areas in industrial engineering which fit into their particular program and which may not be covered by an existing industrial engineering graduate level course. Problems may require individual research and initiative in the application of industrial engineering training to new areas or fields.

Graduate Staff

IE (CSC,OR) 662 Stochastic Simulation Design and Analysis. *Preqs.: CSE (CSC, ECE, IE, OR) 562 and ST 516. 3(3-0) S.* Advanced topics in stochastic system simulation covered, including random variate generation, output estimation for stationary and nonstationary models, performance optimization techniques, variance reduction approaches. Students apply these techniques to actual simulations. A paper written on a current research topic required.

Bengston, Perros,

IE (CSC, ECE) 675 Advanced in Voice Input/Output Communications Systems. *Preq.: IE (CSC, CSE, ECE) 575. 3(2-3) S.* Selected topics from the current literature in voice input/output research, technology and applications. Each student must carry out a significant experiment or project.

Rodman

IE (OR, MA) 692 Special Topics in Mathematical Programming. *Preq.: IE (MA, OR) 505. 3(3-0) F,S,Sum.* The study of special advanced topics in the area of mathematical programming. New techniques and current research in this area discussed. The faculty responsible for this course select the areas to be covered during the semester according to their preference and interest. This course not necessarily taught by an individual faculty member but can, on occasion, be a joint effort of several faculty members from this university as well as visiting faculty from other institutions. To date, a course of Theory of Networks and another on Integer Programming have been offered under the umbrella of this course. It is anticipated that these two topics will be repeated in the future together with other topics.

Graduate Staff

IE 693 Seminar in Applied Ergonomics. *Preqs.: IE (PSY) 540, ST 515. 1(0-2) S.* Discussion of contemporary issues involving the systems approach to accident prevention

and injury control. History of safety research; federal health, industrial and military activities in safety, current centers of safety research and their activity. Ayoub, Pearson

IE 694 Advanced Problems in Ergonomics. *Preqs.: IE (PSY) 540, ST 515. 3(3-0) F.* Exploration in depth of a problem area of contemporary interest involving the man-machine-environment interface. Class discussion and analysis of research and theory, with special focus on the human factors aspects of systems design and operation.

Antin, Ayoub, Pearson

IE 695 Seminar. *1(1-0) S.* Seminar discussion of industrial engineering problems for graduate students. Case analyses and reports.

Graduate Staff

IE 699 Industrial Engineering Research. *Preq.: Grad. standing. Credits Arranged. F,S,Sum.* Graduate research in industrial engineering for thesis credit.

Graduate Staff

Integrated Manufacturing Systems Engineering

Professor C. F. Zorowski, Director

Approximately twenty faculty from six different departments serve as the graduate faculty for the IMSE degree program. A list of these participants is available from the IMSE Institute Office.

The Integrated Manufacturing Systems Engineering program was established in 1984 to provide an interdisciplinary course of study in manufacturing systems at the graduate level. The program is administered through the Integrated Manufacturing Systems Engineering Institute, a multifaceted educational, research and technology transfer organization within the College of Engineering. The objective of the academic program is education in the theory and practice of advanced design and manufacturing methods. Central to all aspects of the Institute's program is the integration of computer-aided techniques in the design of both product and process and in the control of manufacturing facilities. The development and application of this technology require a specially structured academic and research program to produce graduates capable of bringing about the productivity and quality gains desired by industry.

The academic focus of the Institute is a multidisciplinary master's degree program consisting of courses offered by the Departments of Electrical and Computer Engineering, Industrial Engineering, Mechanical and Aerospace Engineering, Computer Science, and Economics and Business. The degree program provides flexibility to meet the changing needs of industry and students. An interdisciplinary minor is also available for students who wish to pursue an M.S. or Ph.D. program in a specific department. The goal of the degree program is to provide an academic background essential to the understanding and implementation of computer integrated manufacturing systems.

The IMSE degree does not include specified major and minor areas of study as normally found in classical master's degree programs. By its very nature, the manufacturing function is multidisciplinary, cutting across traditional engineering disciplines as well as others including economics, business and computer science. The development and use of computer technology in modern manufacturing systems for planning, design, control and information access requires a multidisciplinary approach.

A typical program of study extends over sixteen months for a student supported on a half-time assistantship. However, it is possible to complete the academic program in as few as twelve months. The curriculum includes a minimum of 27 credit hours of graduate course work in addition to participation in the research activities of the Institute for six hours of credit. Additional course work may be required, dependent upon the background of the student. This may be in the form of immigration modules, or undergraduate courses, for which no graduate credit is received. At least six credit hours must be at the advanced graduate level. The IMSE degree does not require a thesis; however, a comprehensive technical report must be prepared by each student on the required six-credit-hour research project.

The general plan of study for the IMSE degree consists of three components: core courses, concentration electives and a research project.

<i>Program Requirements</i>	<i>Credit Hours</i>
Core Courses (5)	15
Concentration Electives (4)	12
Research Project	6
Total Hours	33

Five core courses, required of all students, present an interdisciplinary overview of subject material basic to manufacturing systems. Subject matter specialization is provided in the student's plan of work through the selection of a minimum of four electives in an area of concentration. The five following concentrations are offered by the Institute:

- 1) Manufacturing Automation
- 2) Manufacturing Operations Management
- 3) Design for Manufacture
- 4) Sensors, Controls and Robotics
- 5) Artificial Intelligence and Information Handling

Over thirty courses are available in the concentration areas. A list of these offerings can be obtained from the Institute. The six credit hours of required individual or team research project complement and reinforce the area of concentration.

<i>Core Courses:</i>	<i>Credit Hours</i>
IE 516 CAM I: A Systemic Approach to Computer-aided Manufacturing	3
IE 518 Manufacturing Operations Management	
or	
IE 523 Production Planning, Scheduling and Inventory Control	3
MAE 542 Design for Automated Assembly	3
IE 511 Capital Investment Economic Analysis	
or	
EB 520 Managerial Finance: Theory and Application	3
CSC 510 Software Engineering	
or	
CSC 542 Database Management	
or	
CSC 562 Computer Simulation Techniques	3
Total Credit Hours	15

The academic program of each student is tailored to meet specific goals and interests. Suggested plans of study in several concentration areas can be obtained by contacting the Program Director in the IMSE Institute Office.

The student's advisory committee is made up of three or more members of the graduate faculty who associate with and participate in the activities of the Institute. The chairman is normally chosen from the area of concentration the student has selected. Other members of the committee come from supporting areas of the program.

Each student is required to pass a final oral examination as a degree requirement. This examination consists principally of a formal presentation and defense of the student's participation and accomplishments in the research project activity. The student's advisory committee administers the final examination. There may be instances in which simultaneous examinations are desirable depending on the nature, breadth and complexity of a specific project. The work of individual students may complement each other's activities such that a total team presentation may be beneficial. In such instances the advisory committees will be present for each student and each advisory committee will exercise its own prerogatives and authority. One committee chairman will be selected out of the entire group by all chairmen to moderate the presentation and defense activity.

FOR GRADUATES ONLY

IMS 698 Manufacturing Systems Engineering Project. *Prereqs.: Grad. standing in IMSE; CI. 1-3 F.S.* Individual or team project work in integrated manufacturing systems engineering resulting in an engineering report. Required of all degree candidates in IMSE master's program. Forms the basis for IMSE student's final oral examination.

International Development

Professor J. L. Apple, Coordinator

The degree of Master of Technology for International Development (MTID) gives an international orientation to the master's degree which is sought in any of the scientific, social and professional fields represented at this university. At a time when the world is moving inexorably toward greater interchange of people and increased commerce among nations, the MTID program provides specialized training for students who are interested in utilizing their skills in international activities, whether technical, consultative or administrative in nature.

The program of work requires the following:

- 1) A total of 36 semester credits, at least half of which must be in the relevant professional area. The remainder of the course work provides special orientation, sensitivity and understanding for work in a foreign culture. Among these "internationalizing" courses, 12 semester credits may be drawn from courses at the 300 or 400 levels with no more than six credits being taken from the 300 level.
- 2) A work experience of a minimum of 12 weeks in a foreign country and a substantial report on that field experience.
- 3) Conversational facility in one foreign language as determined by an oral examination.
- 4) A comprehensive written examination, which may be required at the discretion of the advisory committee.

5) Passage of a comprehensive oral examination conducted by the advisory committee.

The program of study is tailored to the student's individual needs rather than following a prescribed course; therefore, the student is expected to be able to demonstrate maturity and assume initiative in planning his/her own course of study. The relevant department assists in choosing a set of courses which provide grounding in the professional area, and the Office of International programs assists in identifying appropriate "internationalizing" courses which satisfy the student's particular needs and interests.

The following exemplify MTID plans of study:

Example 1—Core Area: Animal Science

Courses in Animal Science

ANS 502	Reproductive Physiology of Vertebrates	3
ANS 508	Genetics of Animal Improvement	3
ANS 510	Advanced Livestock Management	3
ANS 520	Tropical Livestock Production	3
ANS 540	Ruminant Physiology and Metabolism	3
PO 524	Comparative Endocrinology	4
		19

"Internationalizing" Courses

EB 401	Economics Analysis for Nonmajors	3
HI 476	Leadership in Modern Africa	3
HI 498	Independent Study in History	3
PS 533	Global Problems and Policy	3
PS 431	International Law and Organization	3
SOC 652	Comparative Societies	3
		18

Total semester hours 37

Example 2—Core Area: Public Administration

Courses in Public Administration

PA 511	Public Administration	3
PA 516	Public Policy Analysis	3
PA 612	The Budgetary Process	3
PA 614	Management Systems	3
PA 617	Seminar in Organization Theory	3
PA 621	Collective Negotiations in the Public Service	3
		18

"Internationalizing" Courses

EB 448	International Economics	3
HI 415	Revolutionary Europe	3
HI 554	History of U.S. Foreign Relations, 1900-Present	3
PS 641	Seminar in Comparative Politics	3
SOC 503	Contemporary Sociology	3
SOC 514	Developing Societies	3
		18

Total semester hours 36

Recognition that the interdependence of nations and the free exchange of ideas and technology is vital to global survival is now commanding greater attention than at any other time in history. The MTID program is a sophisticated response that equips graduates with the social, philosophical and technical skills necessary for employment with national and international organizations (profit and non-profit), business firms and government agencies.

General requirements for admission to the MTID program include a Bachelor's degree from an accredited college or university, a grade point average of 3.0 ("B") in one's undergraduate major and satisfactory performance on the Graduate Record Exam.

Landscape Architecture

GRADUATE FACULTY

Associate Professor D. W. Dalton, Acting Program Director

Professors: R. C. Moore, J. C. Raulston Jr., A. L. Sullivan, R. R. Wilkinson;
Professors Emeriti: R. E. Stipe, E. G. Thurlow; *Associate Professors:* A. R. Abbate, D. Wood; *Assistant Professors:* W. E. Hooker, F. H. Magallanes;
Lecturers: R. S. Altman, R. M. Leary, M. E. E. Traer

The Master of Landscape Architecture degree at NCSU is fully accredited by the Landscape Architecture Accreditation Board to prepare students from many academic backgrounds for careers in landscape architecture. Advanced standing is available for students offering undergraduate work in landscape architecture or closely allied subjects. Students without advanced standing should expect to spend the equivalent of three academic years completing the program.

The MLA degree is both a first professional degree as recognized by state registration boards and the professional society (American Society of Landscape Architects) as well as a Master's degree in a designated field as described by the Graduate School of NCSU.

For students without preparation in landscape architecture, the beginning phase of the program introduces the means by which the landscape is creatively altered. Impacts of alteration to the systems of rock, soil, water, flora and fauna are considered and evaluated against the social and economic benefits of the proposed use, and a well-designed accommodation is sought within the traditions of the profession's practical arts and techniques.

Prior to beginning the second or scholarship and research phase of the program, a graduate advisory committee is nominated by the student, approved by the department head, and formally appointed by the Dean of the Graduate School. The student and this committee of three faculty advisers constructs a list of courses and a final project proposal, constituting a Plan of Graduate Work which is submitted for approval to the Graduate School. When approved, the Plan serves as a contract for the degree. It may be altered by petition but gives the student a clear idea of the path ahead. The Plan of Graduate Work focuses the student's program in one of three concentrations: site planning and construction, community design, or environmental management, described below. A minor

field of study is also specified, for example, horticulture, architecture, computer science, forestry, psychology, etc.

The beginning phase of the program is structured and developmental. Students acquire the skills and traditions of professional practice in both the private and public sectors. Site planning, construction, planting, graphics, history and design policy are taught in three-credit courses. Design is taught in six-credit studios. One studio and two courses per semester constitute a normal graduate load. Our academic year is divided into fall and spring semesters and two six-week summer sessions.

SELECTED ADVANCED UNDERGRADUATE COURSE

LAR 400 Landscape Architecture Studio. *Preqs.: School of Design majors: DF 102; Horticultural Science-Landscape Technology option majors: LAR 234. 6(0-9) F,S.*

LR 430 Site Planning. *Preqs.: MEA 101/110 or MEA 120/110 or SSC 200. 3(2-3) F.*

LAR 433 Native Plants in Environmental Design. *Preqs.: DN 221 or DN 232, HS 211. 3(2-2) S.*

LAR 444 History of Landscape Architecture. *3(3-0) F.*

LAR 457 Landscape Construction Materials, Methods and Documentation. *Preq.: LAR 430. 3(2-3) S.*

LAR 494 Internship in Landscape Architecture. *Preqs.: Jr. standing in LAR and 3.0 GPA or better and approval of department head. 3-6 F,2.*

LAR 495 Independent Study in Landscape Architecture. *Preqs.: jr. standing in LAR and 3.0 GPA or better and approval of department head. 3-6. F,S.*

FOR GRADUATES AND ADVANCED UNDERGRADUATES

LAR 510 Graphics for Landscape Architects. *Preq.: Grad. standing or CI; Coreq.: LAR 600 or CI. 3(3-0) F.* A series of demonstrations and exercises organized to give students exposure to and experience with conventional techniques of graphic representation and presentation.

LAR 511 Community Design Policy. *Preq.: Grad. standing or CI. 3(3-0) S.* The course explores the theory and practices of the social policy impact on the designed environment and users of that environment. The public community development process studied as it relates to the built environment.

LAR 512 Landscape Resource Management. *Preq.: CI. 3(1-4) S.* Laboratory techniques course in the methodology of analysis and management of natural resources as it relates to landscape architecture. Case study approach to managed resource systems using spatial mapping and analysis techniques.

LAR 521 Values, Theory and Methods of Landscape Architecture. *Preq.: Grad. standing. 3(3-0) F.* The profession of landscape architecture has undergone radical change in the past decade. Regional analysis, landscape assessment, land development, urban planning, recreation planning, etc., are new and emerging roles for the landscape architect. This course develops the core values and theories from which each have emerged and surveys the techniques and methods of their development.

LAR 530 Advanced Site Planning. *Preqs.: LAR 430. 3(2-2) S.* An expansion of fundamental site planning techniques applied to development of design proposals including grading, utilities, layout plans, hydrologic calculations, details and specifications.

LAR 531 Project Planning and Design. *Preq.: Grad. standing or CI; Coreq.: LAR 600. 3(3-0) S.* Procedures and issues in project planning, activity programming and site development discussed in conjunction with three assigned projects.

LAR 533 Plants and Design. *3(2-2) F.* The course examines three landscape types: natural landscapes, landscapes altered by man and designed landscapes. Investigation of relevant plant materials and planting design processes utilized to reveal natural principles as the basis for a design theory and methodology. Course assignments range from an analysis of actual plant materials and landscapes to the preparation of contract documents.

LAR 551 Ethics of Professional Practice in Landscape Architecture. *3(3-0) S.* An examination of the place of the professional in society, the contents and philosophies of various professional codes of ethics, the relationship of the practitioner with clients, peers and the public interest. It includes preparation of proposals, conduct as an expert witness, office organization and contracts.

LAR (RRA) 562 Computer Cartography. *3(3-0) S.* (See recreation resources administration.)

LAR 564 Management and Marketing Techniques in Community Design. *3(3-0) S. Alt. yrs.* Methods for effective management of community design processes. Emphasis on personal management skills, group process techniques, publicity materials, public relations and marketing strategies. A technical assistantship with a local agency/organization required.

LAR 573 Historic Preservation. *Preqs.: Grad. standing and CI. 3(3-0) F.* Seminar covering the legal, administrative, fiscal and political aspects of preserving and conserving buildings, sites, districts, objects and landscapes of architectural, historical and design significance as related to community design and planning considerations. Subjects to be treated include federal, state and local statutes and ordinances; federal and state court decisions and administrative processes.

LAR 574 Landscape and Townscape Conservation. *Preqs.: LAR 511. 3(3-0) S.* Examination of local, state and federal law affecting the visual quality of large-unit natural and built environments such as landscapes and townscapes, as expressed in local ordinances, state statutes, executive orders, administrative regulations and court decisions. Emphasis placed on the legal, administrative, fiscal and governmental tools and processes for maintaining and enhancing visual environmental quality.

LAR 575 Development Planning. *Preq.: Grad. standing or CI. 3(3-0) F,S.* The seminar presents the concepts, processes and principles used in the design and development of communities. The discussions focus on a general development process, the development team and the role of the designer in the context of the team. A wide range of project types discussed. The seminar presents the relationships of public regulatory policies and programs to the community design and development process.

LAR 576 Master Planning and Design Management. *Preq.: Advanced undergrad. or grad. standing. 3(3-0) S. Alt. yrs.* Case studies in master planning and design management of "multi-designer" environments such as planned communities, historic districts, urban centers, college campuses, retail centers, expos, and corporate and governmental building programs. Analysis of design review procedures. Emphasis on collaborative design methods. Students prepare and implement a master plan and design management system.

LAR 592 Special Topics. *Preq.: Grad. standing. 2-3 F,S.* Topics of current interest to the programs in the School of Design offered by faculty in the School. Subjects offered under this number are normally used to test and develop new courses.

LAR 595 Independent Study. *Preq.: Grad. standing. Max. 6. F,S,Sum.* Special problems in various aspects of design developed under the direction of a faculty member on a tutorial basis.

FOR GRADUATES ONLY

LAR 600 Landscape Design Studio. *Preq.: Grad. standing. 6(0-12) F.S.* The application of information and skills developed in course work to environmental design problems. A process of site selection, activity programming, site planning, and program evaluation followed which employs the creation of interactive communication systems between the designer, clients and users. Goals include the design of satisfying new landscapes as well as conservation and design strategies for existing culturally important landscapes and townscapes.

LAR 611 Advanced Community Design and Development Control. *Preq.: LAR 511. 3(1-3) S.* Advanced work in design and application of governmental planning and development control techniques to built environments, and impact of such controls on design solutions at varying scales. Emphasis on design implications of complex control systems: development rights transfer, land use intensity rating systems, planned unit development regulations and other zoning and non-zoning site planning regulations.

LAR 612 Social Factors Analysis in Site Planning. *Preq.: LAR 511 or CI. 3(2-1) S.* The course explores social factors techniques and research applications to the design of the landscape. Interaction, neighborhood theory and user preference analysis techniques presented through discussion and development of research and case studies.

LAR 691 Degree Seminar. *Preqs.: 3 LAR 600 studios. 0.* Each student in his or her terminal semester not registered in any other courses and in conjunction with the terminal case study will prepare and submit to his or her committee a presentation on the relevance of one's minor to the design process with particular reference to the individual's case study.

LAR 698 Advanced Research Projects. *Preqs.: 2 LAR 600 studios or CI. 2-6 F.S.* Graduate students sufficiently prepared may undertake selected research investigations. A proposal for such investigations must be submitted prior to consent for enrollment.

Liberal Studies

GRADUATE FACULTY

Professor C. D. Korte, Director

The Master of Arts in Liberal Studies (MALS) program is an interdisciplinary graduate program which is administered by the Division of University Studies. This is a broad, interdisciplinary program of part-time graduate study that integrates and expands awareness and that is geared to the student's personal interests. Each student, in consultation with an academic advisor, designs an individual program of study around an interdisciplinary theme or topic that is of intrinsic interest to the student or that relates to the student's professional or vocational interests. Students take graduate courses across a range of NCSU departments as well as MALS seminars designed specifically for the program.

The degree requirements consist of 30 hours of course work made up of (1) a minimum of three MALS seminars, (2) eighteen hours representing the student's interdisciplinary theme or concentration, and (3) a three-credit-hour culminating project. Each semester a number of MALS seminars are offered for MALS students. Examples of concentrations that are well supported by graduate courses in the NCSU curriculum are: science, technology and society; national and international issues and decision making; and the American experience.

This program is offered jointly by the Colleges of Humanities and Social Sciences and Physical and Mathematical Sciences.

FOR GRADUATES ONLY

MLS 600 Proseminar in Liberal Studies. *Preq.: Admission to M.A. in liberal studies. 3(3-0) F,S,Sum.* Introductory interdisciplinary proseminar for the Master of Arts in liberal studies program. Analysis of disciplinary vs. interdisciplinary inquiry and examination in detail of an interdisciplinary topic. Topic varies from semester to semester.

MLS 601 Seminar in Liberal Studies. *Preq.: Admission to M.A. in liberal studies. 3(3-0) F,S,Sum.* Intensive study of an interdisciplinary issue or area. Seminars, which vary each semester, address such topics as the information revolution, defining the American West, sociobiology and the social sciences, world trade and world conflict, and technology and social disruption.

MLS 696 Independent Study in Liberal Studies. *Preq.: Admission to M.A. in liberal studies. 1-6 F,S,Sum.* Advanced independent study of an interdisciplinary topic under the supervision of a faculty member.

MLS 697 Independent Project in Liberal Studies. *Preq.: Admission to M.A. in liberal studies. 3(3-0) F,S,Sum.* Advanced independent research on an interdisciplinary project under the supervision of a faculty member.

Management

Associate Professor S. E. Margolis, Director

Graduate Advisor and Program Assistant B. L. Puryear

PROGRAM COMMITTEE

G. F. Abbott, *Telecommunications Systems Engineering*; F. B. Armstrong, *Biotechnology*; G. A. Berkstresser, *Textiles*; R. H. Bernhard, *Industrial Engineering*; W. Chou, *Computer Studies*; S. E. Elmaghraby, *Operations Research*; T. L. Honeycutt, *Management Information Systems*; D. W. Johnston, *Civil Engineering*; C. P. Jones, *Economics and Business*; T. W. Reiland, *Statistics*

GRADUATE FACULTY

Professors: S. G. Allen, F. B. Armstrong, J. R. Canada, G. A. Carlson, R. L. Clark, D. A. Dickey, E. W. Erickson, D. Fisher, A. R. Gallant, T. J. Grennes, J. D. Hess, D. M. Holthausen, L. A. Ihnen, P. R. Johnson, T. Johnson, C. R. Knoeber, J. J. Seater, V. K. Smith, W. A. Smith, D. A. Sumner, K. C. Tai; *Associate Professors:* E. W. Davis Jr., J. C. Dutton Jr., D. J. Flath, T. L. Honeycutt, J. S. Lapp, S. J. Liebowitz, E. A. McDermed, M. B. McElroy, R. B. Palmquist, J. W. Rockness, R. J. Rossana, W. N. Thurman, G. J. Zuckerman; *Assistant Professors:* E. F. Gehringer, K. Mitchell, C. M. Newmark, R. R. Rucker; *Adjunct Assistant Professor:* C. B. Oldham

The Master of Science in Management (MSM) program provides management education in the land-grant tradition. Drawing on the historical strength of North Carolina State University in applied economics, statistics and technology,

the MSM program prepares students for careers that will extend well into the twenty-first century. Successful management requires not only an awareness of current business practices, but also the theoretical background necessary to understand when and why these practices work and when they must be modified. The MSM program has strong emphasis on theory and quantitative skills to meet these requirements.

The MSM degree is offered jointly by nine academic areas: economics and business, biotechnology, civil engineering, computer science, industrial engineering, operations research, statistics, telecommunications systems engineering, and textile and apparel management. The range of faculty expertise and courses available distinguishes the MSM from other graduate management programs and provides the MSM student with flexibility in selecting a set of courses that will complement their background and career interests.

The MSM program requires 36 semester hours of graduate course work consisting of seven core courses required of all students and five courses to be chosen in a technical option.

Included in the core are graduate-level micro- and macroeconomics courses (EB 501 and EB 502) which consider the theory of business decisions and the determinants of the economic environment in which business operates. Statistical methods (ST 514, 512 or 508) and Introduction to Operations Research (OR 501) provide useful analytical tools. The remainder of the core includes managerial finance (EB 520), marketing (EB 560), and an elective to be selected from one of the following: advanced managerial accounting (ACC 520), personnel management (EB 526), or long-range planning (EB 625).

Suggested technical options have been prepared by each of the participating departments and examples are provided below. Complete course offerings are listed by department throughout this bulletin. Courses from one or more areas may be combined to develop an option that complements the academic and career interests of the individual student.

Economics and Business

- EB 512 Law and Economics
- EB 522 Portfolio and Capital Market Theory
- EB 525 Managerial Economics
- EB 606 Industrial Organization and Control
- EB 650 Economics Decision Theory

Biotechnology

- GN 411 Principles of Genetics
- GN 695 Special Problems in Genetics
- FS 504 Food Proteins and Enzymes
- FS 691 Special Research Problems in Food Science
- EB 625 Long Range Planning in Business and Industry

Civil Engineering

- CE 464 Legal Aspects of Contracting
- CE 561 Construction Planning and Scheduling
- CE 562 Construction Productivity
- CE 566 Building Construction Systems
- CE 665 Construction Equipment Systems

Computer Studies

- CSC (ECE) 501 Design of Systems Programs
- CSC 505 Design and Analysis of Algorithms
- CSC (ECE) 510 Software Engineering
- CSC (ECE) 542 Database Management
- CSC (ECE) 671 Advanced Computer Performance Modelling

Industrial Engineering

- IE 511 Capital Investment Economic Analysis
- IE 512 Bayesian Decision Analysis for Engineers and Managers
- IE 521 Management Decision and Control Systems
- IE 525 Organizational Planning and Control
- IE 621 Advanced Problems in Management Systems Engineering

Management Information Systems

- CSC 421 Introduction to Management Information Systems
- CSC 423 Information Resources Management
- CSC (ECE) 510 Software Management
- CSC (ECE) 542 Database Management
- IE 521 Management Decision and Control Systems

Operations Research

- OR (IE, MA) 505 Linear Programming
- OR (IE) 509 Dynamic Programming
- OR (IE, MA) 586 Network Flows
- OR (MA, ST) 606 Nonlinear Programming
- OR (MA) 614 Integer Programming

Statistics

- ST 421 Introduction to Mathematical Statistics I
- ST 422 Introduction to Mathematical Statistics II
- ST 517 Applied Least Squares
- ST 518 Applied Time Series Analysis
- ST (EB) 651 Econometrics

Telecommunications Systems Engineering

- EB 590N Special Economics Topics: Economics and Management of Telecommunications and Public Utilities
- CSC 495N Special Topics in Computer Science: Data Networks
- ECE 492X Special Topics in Electrical and Computer Engineering: Introductory Concepts in Communications Systems
- ECE 592R Special Topics in Electrical and Computer Engineering: Telecommunications Systems Engineering
- OR (IE) 561 Queues and Stochastic Service Systems

Textile and Apparel Management

- TAM 530 Textile Quality Control
- TAM (EB) 585 Market Research in Textiles
- TAM 680 Special Projects in Textile Management
- TAM 686 Advanced Textile Labor Management Seminar
- TAM 687 Competitive Strategy and Planning for the Textile Firm

A project paper and a final oral examination are required of each student. The project paper is usually written in conjunction with one of the 600-level courses and often involves an analysis of a problem faced by a local business firm. Defense

of the paper constitutes the basis for the final oral examination that is conducted by the student's graduate advisory committee.

Prerequisites for the MSM program include two semesters of calculus and one semester each of intermediate microeconomics and macroeconomics. Generally a student should complete these courses before applying for admission. Domestic students may complete this course work by registering through the Division for Lifelong Education in a special part-time preparatory program, Post-baccalaureate Studies (PBS). Submission of the Graduate Management Admission Test (GMAT) or the Graduate Record Exam (GRE) is highly recommended but not required.

In addition to the prerequisite calculus and economics course work, the MSM program requires that students have an undergraduate-level foundation in financial and managerial accounting, introductory computer science (including some programming) and statistical methods (including regression and analysis of variance). Students who have not completed these foundation courses in recent undergraduate work should take them early in their graduate programs.

The MSM program is available to students interested in part-time and full-time studies. Approximately two-thirds of the current student enrollment is part-time. All core courses and many of the electives are offered in the evening on a rotating basis for individuals interested in part-time evening studies. Students should consult the program advisors for further information on evening study.

A wide range of employers have found the analytical nature of the MSM program to be very attractive. Recent graduates have been employed by many firms, governmental agencies and nonprofit institutions in North Carolina and other states. The services of the University's Career Planning and Placement Center are available to all students. In addition, economics and business employs a placement counselor to serve its current students and recent graduates.

For additional information, contact B. L. Puryear, Graduate Advisor, Economics and Business, Box 8109, North Carolina State University, Raleigh, NC 27695-8109, phone (919) 737-7157, or any member of the Program Committee.

Marine, Earth and Atmospheric Sciences

GRADUATE FACULTY

Professor L. J. Pietrafesa, Head

Professor G. S. Janowitz, Graduate Administrator

Professors: C. E. Anderson, S. P. S. Arya, V. V. Cavaroc Jr., J. M. Davis, R. V. Fodor, D. Kamykowski, S. Raman, V. K. Saxena, C. W. Welby, T. G. Wolcott, I. J. Won; *Adjunct Professor:* R. L. Bradow; *Professors Emeriti:* H. S. Brown, L. J. Langfelder, C. J. Leith, J. M. Parker III, W. J. Saucier; *Associate Professors:* M. G. Bevis, D. J. DeMaster, M. M. Kimberley, C. E. Knowles, J. M. Morrison, A. J. Riordan, W. J. Showers, E. F. Stoddard, G. F. Watson; *Visiting Associate Professors:* V. P. Aneja, D. L. Wolcott; *Assistant Professors:* N. E. Blair, S. Businger, D. M. Checkley Jr., J. P. Hibbard, L. A. Levin, E. L. Leithold, Y.-L.

Lin, P.-T. Shaw, J. A. Speer: *Adjunct Assistant Professors*: T. B. Curtin, M. DeMaria

ASSOCIATE MEMBERS OF THE DEPARTMENT

Professors: B. J. Copeland, F. Y. Sorrell Jr., C. C. Tung; *Associate Professor*: J. M. Miller

The Department of Marine, Earth and Atmospheric Sciences offers graduate programs leading to the M.S. and Ph.D. degrees.

The Atmospheric Science areas of specialization include atmospheric dispersion, boundary layer flows and air quality; mesoscale and severe weather phenomena; synoptic weather systems and weather forecasting; climatology and agricultural meteorology; cloud and aerosol physics and atmospheric chemistry.

Areas of specialization in Earth Science include mineralogy, igneous and metamorphic petrology, sedimentology and sedimentary petrology, sedimentary geochemistry, economic geology, global and exploration geophysics, structural geology, hydrogeology and marine geology. As geology and geophysics are considered distinct areas of study, students can major in one area and minor in the other.

In Marine Science, areas of specialization are biological, chemical, geological and physical oceanography, geophysical fluid dynamics and marine meteorology.

Admission with a specialization in Atmospheric Science requires a bachelor's degree in meteorology or other technical areas which include a background in chemistry, physics and mathematics. Candidates in Earth Science should hold a bachelor's degree in geology or a satisfactory equivalent, preferably with a strong background in physics, chemistry and mathematics. Graduate students in Marine Science are normally admitted after having received a baccalaureate degree in biology, chemistry, engineering, geology, mathematics, physics or meteorology.

In each discipline the master's program includes a minimum of 30 semester credit hours. Doctoral programs normally contain at least 50 semester credit hours beyond the B.S. degree, although course requirements are determined by the student's advisory committee. Graduate work includes major and minor fields and a research thesis. An M.S., non-thesis option is also available. Marine Science students are expected to be familiar with areas of marine studies other than their own and are required to complete two (three) courses from other Marine Science core areas in the M.S. (Ph.D.) program.

Sponsored research is being conducted in various areas of geology and geophysics, in air pollution and boundary layer meteorology, cloud and aerosol physics, and in Marine Science, in continental shelf, Gulf Stream and climate dynamics, geophysical fluid dynamics, sediment transport and water column and benthic biology. Graduate students are actively involved in the conduct of the research which often forms the basis of their theses. Research projects range from theoretical studies to international field experiments. Regional studies are being performed within the North Carolina Blue Ridge, Piedmont and Coastal Plain as well as in estuaries, on the continental shelf and slope and in the Caribbean Sea and Indian Ocean.

Research facilities are available for analytical work in most areas of geology, geophysics and atmospheric sciences. Biological, chemical, geological and physical oceanography laboratories and shop facilities for electronic and mechanical equipment repair and fabrication are available for student use. Students also have on-campus access to the TUCC IBM System 370/165 and Amdahl computers and to several smaller computing facilities operated by the department. Remote sensing capabilities are utilized in both research and classroom instruction. Collections of pertinent literature are available in the University library and elsewhere in the Research Triangle area. Consultation with scientists of the federal and state agencies in Raleigh as well as with the staffs of the neighboring universities is possible and encouraged.

The State of North Carolina operates three Marine Resources Centers on our coast where research space is available. Our students have also made use of facilities at Duke University's Marine Laboratory and the National Marine Fisheries Laboratory, both on Pivers Island, North Carolina. The department has a small boat and is a member of the Duke/UNC consortium that operates the new 131 ft. R/V Cape Hatteras.

Financial aid is available through both teaching assistantships (9 month) and research assistantships (9 or 12 month). Government agencies and industry occasionally provide part-time employment and small grants from the State are sometimes available to assist with thesis expenses.

Atmospheric Science

SELECTED ADVANCED UNDERGRADUATE COURSES

MEA 412 Atmospheric Physics. *Preqs.: MA 202, PY 208 or equiv. 3(3-0) S.*

MEA 421 Air Processes and Motions I. *Preqs.: MA 202, PY 208, MEA 311, 312, 313, 314. 4(3-2) F.*

MEA 422 Air Processes and Motions II. *Preq.: MEA 421. 4(3-2) S.*

MEA 443 Weather Analysis and Forecasting I. *Preq.: MEA 421. 3(1-6) F.*

MEA 444 Weather Forecasting Principles. *Preq.: MEA 443. 3(2-3) F.*

MEA 455 Micrometeorology. *Preq.: MEA 422 or MAE 402. 3(3-0) F.*

MEA 493 Special Topics in Meteorology. *Preq.: Consent of department. 1-3 F,S,Sum.*

FOR GRADUATES AND ADVANCED UNDERGRADUATES

MEA 501 Environmental Fluid Mechanics. *Preqs.: MA 202, PY 208. 3(3-1) F.* Basic concepts and the laws governing the motion of the atmosphere and oceans developed from first principles, including approximations valid for environmental flows, the kinematics, dynamics and thermodynamics of fluid flows as well as an introduction to environmental turbulence.
Arya, Janowitz

MEA 512 Satellite Meteorology. *Preq.: MA 202; Coreq.: MEA 443. 3(3-0) S. Alt. yrs.* Basic background in satellite orbits, coordinate systems and image navigation; description of sensors and techniques for quantitative measurement of atmospheric variables. Applications of satellite data in analysis of weather systems; evolution of convective systems, tropical disturbances and mid-latitude cyclones as revealed by visible and infrared imagery; current research in satellite applications.
Businger, Riordan

MEA 514 Advanced Physical Meteorology. *Preqs.: MEA 412, 421. 3(3-0) F.* The fundamental laws and concepts of thermodynamics and electromagnetic radiative transfer considered in an atmospheric context. These principles then applied to a number of meteorological problems, including those of radiative climate models, the global energy balance, atmospheric aerosols, lidar/radar backscatter and remotely sensed temperature fields.

Saxena

MEA 524 Dynamic Meteorology. *Preq.: MEA 422 or equivalent. 3(3-0) F.* A brief review of the classical and physical hydrodynamics; scale analysis of dynamic equations; atmospheric instabilities; dynamics of tropical convections; perturbation theory and approximations for atmospheric wave motions.

Lin

MEA 525 Numerical Weather Prediction. *Preqs.: MEA 524, CSC (MA) 427 or equivalent and some FORTRAN programming experience. 3(3-0) F, S. Alt. yrs.* Physical and mathematical basis of numerical weather prediction with computer experiments to demonstrate principles and techniques. Topics include derivation of sets of prediction equations consistent with scale analysis and dynamical constraints; atmospheric waves and filtered equations; numerical methods and computational instabilities; filtered and primitive equation models; NWS operational models.

Watson

MEA 526 Air-Sea Interaction. *Preq.: MEA 422 or MEA 560 or CI. 3(3-0) S. Alt. yrs.* Review of basic equations and concepts of turbulent transfer in geophysical flows, air-sea interaction processes and their importance to man's activities, theory and observation of wind-generated ocean surface waves, turbulent transfers in the planetary boundary layer of the marine atmosphere, oceanic mixed layer, development of thermocline and inversion.

Pietrafesa, Raman

MEA 527 Planetary Boundary Layer. *Preq.: MEA 455 or MEA 526 or CI. 3(3-0) F, S. Alt. yrs.* Review of the basic equations and concepts of planetary boundary layers. Study of the closure problem and semi-empirical theories of turbulence, buoyancy effects on mean flow and turbulence, instrumentation and observational platforms for PBL experiments, observed characteristics of atmospheric boundary layers, numerical and physical modeling of PBL and its parameterization in large-scale atmospheric circulation models.

Arya

MEA 528 Coastal Meteorology. *Preq.: MEA 455. 3(3-0) Alt. yrs.* Importance and complexity of coastal meteorological processes; modification induced by surface inhomogeneities; development of internal boundary layers; thermally induced internal boundary layers; coastal fumigation processes; structure and development of sea and land breezes; analytical and numerical modeling of sea breezes; coastal fronts; storm surges; prediction models for storm surges; cold air outbreaks; baroclinic boundary layer processes near coastal areas.

Raman

MEA 555 Meteorology of the Biosphere. *Preqs.: PY 205 or 211; CH 103 or 107; MA 102 or 112. 3(3-0) F.* A course designed for graduate students in the life sciences, presenting the physical principles governing the states and processes of the atmosphere in contact with earth's surface of land, water and life. Exchanges of heat, mass and momentum analyzed for various conditions of the atmosphere and surface and as a function of season, time and geographic location.

Davis

MEA 556 Air Pollution Meteorology. *Preqs.: MA 201 or 212, PY 208 or 212, CH 103 or 105 or 107 or equivalent. 3(3-0) F.* Wind structure in the atmospheric surface layer and planetary boundary layer; temperature structure and stability; mixed layer and inversions; turbulence intensity and scale; meteorological factors affecting the dispersion of pollutants; diffusion theories and models; diffusion and transport experiments; plume rise, fumigation and trapping; removal processes; effects of buildings and hills; effects of local winds.

Arya

MEA 557 Advanced Cloud and Precipitation Physics. *Preq.: MEA 421 or MEA 412. 3(3-0) F. Alt. yrs.* An analysis of the microstructure of warm and cold clouds and precipita-

tion, cloud microphysics-dynamics interactions, formation of cloud droplets, growth of cloud droplets by condensation, initiation of rain in nonfreezing clouds, formation and growth of ice crystals, precipitation theories, planned and inadvertent weather modification and the problem of acid rain.

Saxena

MEA 558 Atmospheric Aerosols. *Preqs.: CH 103 or 107 and PY 205 or 211; Coreq.: MEA 412, 3(3-0) S. Alt. yrs.* An understanding of aerosols as primary air pollutants, indoor versus outdoor pollution, transformation processes, prediction of atmospheric concentrations, scavenging of aerosols, transport of air pollutants on a regional scale, discussion of national experiments to characterize and study the impact of urban-industrial pollution, tropospheric aerosol and weather, stratospheric aerosol, effect of aerosols on atmospheric warming and cooling and air-quality models.

Saxena

MEA (MAE) 563 Geophysical Fluid Mechanics. *Preq.: MAE 550 or equivalent, 3(3-0) F. Alt. yrs.* The principles of fluid mechanics applied to geophysical systems. Special emphasis placed on those features of these systems, such as almost rigid rotation and stable stratification, which produce unique and important effects. The effects of almost rigid rotations on homogeneous and stratified flows examined in detail.

Janowitz

MEA 593 Special Topics. *Preq.: CI, 1-6 F,S,Sum.* Special topics in meteorology, provided to groups or to individuals.

Graduate Staff

FOR GRADUATES ONLY

MEA 627 Atmospheric Turbulence and Diffusion. *Preq.: MEA 422, 3(3-0) F.* Mechanics of turbulence in the atmosphere, spectra and scales of atmospheric turbulence and magnitudes of turbulent fluctuations. Theories of diffusion in the atmosphere. Diffusion and transport experiments. Processes other than natural turbulence affecting concentration of effluents.

Arya

MEA 635 Dynamical Analysis of the Atmosphere. *Preqs.: MEA 441, 443, 3(2-3) F.* Theory and analysis of circulation and weather systems based on dynamical concepts; structure, movement and development of systems; evaluation of theoretical concepts in prognosis and forecasting.

Lin

MEA (MAE) 663 Advanced Geophysical Fluid Mechanics. *Preq.: MAE 550 or equivalent, 3(3-0) S. Alt. yrs.* The principles of fluid mechanics are applied to geophysical systems. Special emphasis placed on the role of stable stratification on the flows in these systems. The generation, interaction, propagation and dissipation of internal gravity waves studied in detail. Other geophysically important flows also studied.

Janowitz

MEA 695 Seminar. *Preq.: Grad. standing, 1(1-0) F,S.* Presentation of scientific articles and special lectures. Each student required to present or critically review one or more papers.

Graduate Staff

MEA 699 Research. *Preqs.: Grad. standing and consent of advisory committee. Credits Arranged. F,S.* Graduate research in fulfillment of requirements for a graduate degree.

Graduate Staff

Earth Science

SELECTED ADVANCED UNDERGRADUATE COURSES

MEA 415 Geology of Metalliferous Deposits. *Preqs.: MEA 440, MEA 452, 3(2-3) S.*

MEA 423 Invertebrate Paleontology and Biostratigraphy. *Preqs.: MEA 201/210 or ZO 202, 4(3-3) F.*

MEA 440 Igneous and Metamorphic Petrology. *Preq.: MEA 331, 4(3-3) F.*

MEA 452 Sedimentary Petrology and Stratigraphy. *Coreq.: MEA 331. 4(3-3) S.*

MEA 461 Engineering Geology. *Preq.: MEA 101 or 120. 3(3-0) F.*

MEA 465 Geologic Field Camp I. *Preqs.: MEA 351, 440, 452. First part of 6 weeks out-of-state summer field camp. Both MEA 465 and 466 must be taken in the same summer. 3 Sum.*

MEA 466 Geologic Field Camp II. *Preq.: MEA 465. Second part of 6 weeks out-of-state summer field camp. Both MEA 465 and 466 must be taken in the same summer. 3 Sum.*

MEA 470 Principles of Geophysics. *Preqs.: PY 208 or 212; MEA 120 or equivalent recommended. 3(3-0) F.*

MEA 471 Exploration and Engineering Geophysics. *Preq.: MEA 470 or PY 208. Credit may not be received for both MEA 471 and MEA 570. 3(3-0) F.*

MEA 475 Geophysical Field Methods. *Preq.: MEA 471. Credit is not allowed for both MEA 475 and MEA 575. 2 cr. Sum. field camp.*

MEA 476 Seismic Exploration for Oil. *Preqs.: PY 208, knowledge of FORTRAN. Credit is not allowed for both MEA 476 and MEA 576. 3(3-0) S.*

MEA 481 Principles of Geomorphology. *Preq.: MEA 201 or equivalent. 3(2-2) F.*

MEA 491 Seminar on Selected Geologic Topics. *1-3 F.*

FOR GRADUATES AND ADVANCED UNDERGRADUATES

MEA 500 Regional Geology of North America. *Preqs.: MEA 101 or 120, sr. standing. 1-6 F,S.* Field study of classic geologic localities and geomorphic processes not indigenous to North Carolina. Typical areas are New England and adjacent Canada, northern Mexico and southwestern United States and the Pacific Northwest. Representative subjects include the Canadian Shield, Precambrian mineral deposits, the San Andreas fault, desert geomorphology, Grand Canyon stratigraphy, modern and ancient reefs and glaciated volcanoes. Mineral, rock and fossil collecting. Student reports required. Graduate Staff

MEA 510 Geological Oceanography. *Preq.: MEA 452 or equivalent. 3(3-0) F.* A comprehensive overview of the geological aspects of oceanography. Topics include: a) marine geophysics and the evolution of ocean basins, b) sedimentological processes and the formation of marine deposits, c) marine geochemistry and authigenic sedimentation, d) paleoceanography and the interpretation of marine stratigraphy. Showers

MEA 515 Topics in Southern Appalachian Geology. *Preqs.: MEA 351 and MEA 440 or equivalent. 3(3-0) F. Alt. yrs.* Examination of the geology of North Carolina and surrounding areas. Lectures, discussions, reading of and review of current literature and consideration of ideas concerning the geological evolution of the area. A term project on a selected topic required. Required field trips. Stoddard

MEA 522 Petroleum Geology. *Preq.: MEA 452. 3(3-0) S. Alt. yrs.* Properties, origin and modes of occurrence of petroleum and natural gas. Geologic and economic features of the principal oil and gas fields, mainly in the United States. Graduate Staff

MEA 523 Introduction to Subsurface Well Evaluation. *Preqs.: CH 103, PY 212, MEA 120. 3(2-3) F. Alt. yrs.* Principles, uses and interpretation of commonly used wireline technique for structural, lithologic and fluid evaluation of wells. Oriented towards petroleum reserve/evaluations. Cavaroc

MEA 542 Intermediate Petrographic Analysis. *Preq.: MEA 440 or equivalent. 2(0-5) F.* Systematic study of rocks in thin section by means of the petrographic microscope.

Mineralogy, mineral and rock compositions and rock textures applied to an interpretation of the origin and crystallization or depositional history of specimens studied. Suites representative of each of the three major rock groups studied during the first half of the semester; during the remainder of the semester, the student concentrates on suites representative of his/her area of specialization. Cavaroc, Stoddard

MEA 545 Advanced Igneous Petrology. *Preq.: MEA 440. 3(2-2) S. Alt. yrs.* Physico-chemical principles related to igneous petrogenesis. General principles and specific problems including the origin, differentiation and emplacement of magmas and the possible relationships of igneous processes to global tectonics. Fodor

MEA 546 Advanced Metamorphic Petrology. *Preq.: MEA 440. 3(2-2) S. Alt. yrs.* The petrogenesis of metamorphic rocks including conditions of metamorphism, metamorphic facies and facies series, the petrogenetic grid, contact and regional metamorphism, metamorphism and plate tectonics. Heterogeneous chemical equilibrium and application of Gibbs Phase Rule to metamorphic rocks. Thermodynamically valid algebraic and graphical analysis of equilibrium mineral assemblages. Chemical zoning. Petrographic studies of selected metamorphic suites. Speer, Stoddard

MEA 551 Advanced Structural Geology. *Preq.: MEA 351. 3(2-3) F. Alt. yrs.* Principles of rock mechanics and their application in solving geologic problems; finite strain analysis of deformed rocks; advanced techniques of structural analysis; petrofabrics; development of various geologic structures. Course designed to emphasize the application of principles and techniques in the field. Hibbard

MEA 562 Applied Sedimentary Analysis. *Preqs.: MEA 452, ST 361. 3(2-2) F. Alt. yrs.* Extension of MEA 452, with emphasis on coarser grained clastic sedimentary rocks. Sampling of sedimentary population, critical study of assumptions underlying standard measurement techniques; treatment, testing and evaluation of sedimentary data; application to problems in sedimentology. Cavaroc

MEA 564 Depositional Environments and Lithostratigraphy. *Preq.: MEA 452 or grad. standing. 3(2-3) S.* Fabric of large sedimentary basins in terms of the spatial distribution of component major rock facies; current litho-genetic models based upon comparison with recent equivalents; field trips. Cavaroc

MEA 565 Hydrogeology. *Preq.: MEA 452. 3(3-0) S. Alt. yrs.* Occurrence and sources of surface and subsurface water. Relationships of surface water to subsurface water. Rock properties affecting infiltration, movement, lateral and vertical distribution and quality of ground water. Determination of permeability, capacity, specific yield and other hydraulic characteristics of aquifers. Principles of well design, legal aspects of water supplies. Welby

MEA 566 Hydrogeology of Groundwater Pollution and Protection. *Preq.: MEA 565 or CE 543 or equivalent. 3(3-0) S. Alt. yrs.* Hydrogeologic factors associated with protection of groundwater; use of geologic principles and materials to protect groundwater quality; geologic evaluation and monitoring of waste disposal sites, including appropriate models. Welby

MEA 567 Geochemistry. *Preq.: CH 331 or 433. 3(3-0) F. Alt. yrs.* The quantitative distribution of elements in the earth's crust, the hydrosphere and the atmosphere. Application of the laws of chemical equilibrium and resultant chemical reactions to natural earth systems. Geochemical application of Eh-pH diagrams. Geochemical cycles. Isotope geochemistry. Kimberley

MEA 570 Exploration and Engineering Geophysics. *Preq.: MEA 470 or PY 208. Credit in both MEA 470 and MEA 570 is not allowed. 3(3-0) S.* Geophysical methods as applied to exploring the earth's mineral and energy resources and to investigating subsurface geological structure and physical properties. Principles, measurements, analyses, and interpretations of gravity, magnetic, electric, electromagnetic, seismic methods. Research paper required. Won

MEA 572 Laboratory and Field Methods for Investigation of the Seabed. *Preqs.: MEA 510 or CH 107 or MEA 571. 3(2-3) S. Alt. yrs.* An initial lecture and laboratory phase acquaints the student with the use of advanced techniques and instrumentation for chemical and geological oceanographic investigations. A field project in the coastal waters of North Carolina and then allows application of these tools to a specific marine problem.

DeMaster

MEA 575 Geophysical Field Methods. *Preq.: MEA 570. Credit in both MEA 475 and MEA 575 is not allowed. 2(2-week summer camp) Sum. Alt. yrs.* Two-week summer field course. Practical geophysical field measurements using instruments for gravity, magnetic, electric, electromagnetic and radioactivity methods. Data interpretation in terms of subsurface geological structures and their physical properties, locations, sizes and shapes. Students required to register for the course in the second summer session. Location: within the state of North Carolina. Estimated expense: \$150.00. Research paper required.

Bevis, Won

MEA 576 Seismic Explorion for Oil. *Preqs.: PY 208 and knowledge of FORTRAN language. Credit in both MEA 476 and MEA 576 is not allowed. 3(3-0) S.* A comprehensive introduction to the reflection seismic method as applied to exploring oil and gas resources. Seismic instrumentation, field data acquisition, common-depth-point method, deconvolution, digital filtering, migration and seismic stratigraphy of hydrocarbon depositional environments, along with computer-oriented exercises. Research paper required.

Won

MEA 577 Sedimentary Geochemistry. *Preq.: CH 331 or CH 431 or MEA 567 or equivalent background. 3(3-0) S. Alt. yrs.* This course applies thermodynamic data to the calculation of reactions in natural waters at or near the earth's surface. Topics include weathering to form clay minerals, precipitation of economic minerals and carbonate sedimentology.

Kimberley

MEA 583 Photogeology and Remote Sensing. *Preqs.: MEA 101 or 120, MEA 481 or equivalent. 3(2-3) S.* Study and interpretation of aerial photographs and other remotely sensed data for geological information relating to mineral resource exploration and evaluation and geological controls on environmental problems.

Welby

MEA 588 Regional Tectonics. *Preqs.: MEA 351, 440, 452. 3(3-0) S. Alt. yrs.* Methods of study of the tectonic history of major geologic regions in North America and other areas of the world through the application of stratigraphy, petrology and structural geology. Synthesizing regional tectonic patterns and events.

Bevis, Hibbard

MEA 593 Special Topics. *Preq.: Cl. 1-6 F,S.* Special study of some advanced phases of geology.

Graduate Staff

FOR GRADUATES ONLY

MEA 610 Marine Sedimentology. *Preq.: MEA 510. 3(3-0) S. Alt. yrs.* A quantitative examination of sedimentology with specific reference to the marine environment including an introduction to fluid mechanics, sediment transport theory, quantitative models of sedimentation and dynamic stratigraphy.

Leithold

MEA 630 Geotectonics. *Preqs.: MEA 351, 440, 452. 3(3-0) F. Alt. yrs.* In-depth examination of current ideas in plate tectonic theory. Plate tectonic controls on orogeny, orogenic belts, magmatism and metallogeny.

Bevis

MEA 670 Advanced Geophysics I. *Preqs.: MEA 570 and MA 401. 3(3-0) F. Alt. yrs.* Advanced geophysical theories and applications: topics chosen from the potential field theory of Laplace and Poisson, gravity, heatflow, magnetism, electric and electromagnetic fields as means of investigating the earth's internal structure. Understanding geodynamic principles and applications to exploring for mineral and hydrocarbon resources.

Bevis

MEA 671 Advanced Geophysics II. *Preqs.: MEA 570 and MA 401. 3(3-0) F. Alt. yrs.* Advanced geophysical theories and applications: topics chosen from scalar and vector wave propagation phenomena in geophysics, earthquake seismology, focal mechanisms, propagation of body and surface waves, plate tectonics, advanced reflection seismology for oil and gas exploration, electromagnetic waves as applied to mineral exploration. Won

MEA 695 Seminar. *Preq.: Grad. standing. 1(1-0) F,S,Sum.* Scientific articles, progress reports and special problems of interest to geologists and geological and mining engineers discussed. Graduate Staff

MEA 699 Research. *Preq.: CI. Credits Arranged. F,S,Sum.* Lectures reading assignments and reports; special work in geology to meet the needs and interests of the students. Thesis problem. Graduate Staff

Marine Science

FOR GRADUATES AND ADVANCED UNDERGRADUATES

MEA 501 Environmental Fluid Mechanics. *Preqs.: MA 202, PY 208. 3(3-1) F.* Basic concepts and the laws governing the motion of the atmosphere and oceans developed from first principles, including approximations valid for environmental flows, the kinematics, dynamics and thermodynamics of fluid flows as well as an introduction to environmental turbulence. Arya, Janowitz

MEA 510 Geological Oceanography. *Preq.: MEA 452 or equivalent. 3(3-0) F.* A comprehensive overview of the geological aspects of oceanography. Topics include: a) marine geophysics and the evolution of ocean basins, b) sedimentological processes and the formation of marine deposits, c) marine geochemistry and authigenic sedimentation, d) paleoceanography and the interpretation of marine stratigraphy. Showers

MEA (ZO) 520 Principles of Biological Oceanography. *Preqs.: BS 100 and either BO (ZO) 360 or grad. standing. 3(3-0) S.* Biological productivity and trophic relationships in Plankton, Nekton and Benthos; community ecology of selected habitats (estuaries, intertidal zones, coral reefs, deep sea) and adaptation of organisms to the marine environment. Wolcott

MEA 526 Air-Sea Interaction. *Preq.: MEA 422 or MEA 560 or CI. 3(3-0) S. Alt. yrs.* Review of basic equations and concepts of turbulent transfer in geophysical flows, air-sea interaction processes and their importance to man's activities, theory and observation of wind-generated ocean surface waves, turbulent transfers in the planetary boundary layer of the marine atmosphere, oceanic mixed layer, development of thermocline and inversion. Pietrafesa, Raman

MEA (ZO) 534 Marine Benthic Ecology. *Preqs.: ZO 302, ZO 509 or ZO 517 or MEA (ZO) 520. 3(3-0) S. Alt. yrs.* Marine benthic systems in the deep sea and in shallow waters, focusing upon the abiotic and biotic processes which regulate density, diversity and taxonomic and functional composition. Discussions of benthic-pelagic coupling, predation, interspecific competition, biogeography, sampling problems, evolutionary trends, trophic structure and community organization. Levin

MEA (CE) 541 Gravity Wave Theory I. *Preq.: MAE 308 or PY 411. 3(3-0) S.* Classical gravity wave theory with emphasis on the basic mechanics of wave motions, mass transport induced by waves and various conservation laws with their applications in wave study. Knowles

MEA 559 Synoptic Physical Oceanography. *Preq.: MEA 560 or MEA 561. 3(3-0) S. Alt. yrs.* Basic discussion of the techniques and terminology of synoptic physical oceanography; focus on water characteristics and their relationship to currents in the individual oceans; a systematic quantitative description of the character of ocean waters and their movements. Morrison

MEA 560 Principles of Physical Oceanography. *Preqs.: MA 212 and PY 212 or equivalent. 3(3-0) S.* An introduction to the principles and practice of physical oceanography. Subjects to be covered include: the equation of state of seawater; energy transfer to the ocean by thermal, radiative and mechanical processes; the heat budget; oceanic boundary conditions; the geographical distribution of oceanic properties; observational methods; conservation equations; simple waves and tides; physical oceanography of the North Carolina coastal zone. Morrison

MEA 561 Introduction to Physical Oceanography. *Preqs.: MA 301, PY 208 or CI. 3(3-0) F.* An introduction to the descriptive and dynamical features of ocean circulation. Topics to be covered include the physical properties of seawater, oceanic heat budget, fluid mechanics, dynamics of ocean currents, descriptive oceanography, tides and other waves. Morrison

MEA (MAE) 563 Geophysical Fluid Mechanics. *Preq.: MAE 550 or equivalent. 3(3-0) F. Alt. yrs.* The principles of fluid mechanics applied to geophysical systems. Special emphasis placed on those features of these systems, such as almost rigid rotation and stable stratification, which produce unique and important effects. The effects of almost rigid rotations on homogeneous and stratified flows examined in detail. Janowitz

MEA 568 Ocean Circulation. *Preq.: MAE 308 or PY 411. 3(3-0) F.* Basic study of the mechanics of ocean circulation with emphasis on various simple models of circulation systems. Pietrafesa

MEA 569 The Physical Dynamics of Estuaries. *Preqs.: MA 202 or 212; PY 208 or 212 or CI. 3(3-0) S. Alt. yrs.* A physical/dynamical description of estuaries and estuarine processes which occur as a function of tides, atmospheric forcing, river runoff and topography. Includes classification schemes; the development of salt, heat energy and momentum balances; a discussion of biological modeling and sediment transport processes as a function of the physical dynamics; conservative and non-conservative pollution dispersion prediction; and the theoretical, mathematical modeling of estuaries, including those in North Carolina. Pietrafesa

MEA 571 Principles of Chemical Oceanography. *Preq.: CH 107 or equivalent. 3(3-0) F.* Chemical processes which control the composition of the oceans, including discussions of chemical equilibria, biological cycling of nutrients and the use of chemical tracers in the marine environment; the origin and chemical history of the oceans are also considered. DeMaster

MEA 572 Laboratory and Field Methods for Investigation of the Seabed. *Preqs.: MEA 510 and CH 107 or MEA 571. 3(2-3) S. Alt. yrs.* An initial lecture and laboratory phase acquaints students with the use of advanced techniques and instrumentation for chemical and geological oceanographic investigations. A field project in the coastal waters of North Carolina then allows application of these tools to a specific marine problem. DeMaster

MEA 593 Special Topics. *Preq.: CI. 1-3 F,S.* This course provides the opportunity for advanced undergraduate and graduate students to study timely special problem areas in marine science and engineering. Graduate Staff

FOR GRADUATES ONLY

MEA 610 Marine Sedimentology. *Preq.: MEA 510. 3(3-0) S. Alt. yrs.* A quantitative examination of sedimentology with specific reference to the marine environment including an introduction to fluid mechanics, sediment transport theory, quantitative models of sedimentation and dynamic stratigraphy. Leithold

MEA 613 Continental Margin Sedimentation. *Preq.: MEA 510. 3(3-0) S. Alt. yrs.* A detailed examination of the processes and sedimentation active along continental margins. The specific environments explored are the continental shelf, slope and rise. Graduate Staff

MEA 622 Marine Plankton Ecology. *Preqs.: BCH 451 and MA 212 and ZO 419 or equivalents, 3(3-0) F. Alt. yrs.* This course examines the worldwide relationships between the physical-chemical environment and planktonic organisms. Topics include organism descriptions; the effects of light, temperature, salinity, density, water motion and chemical constituents on organisms; interactions among different organisms emphasizing competition and predation; community structure, distribution and succession; and mathematics models of distribution, production and interaction. Kamykowski

MEA (ZO) 623 Advances in Marine Community Ecology. *Preqs.: ZO 302 and ZO 517 or ZO 560 or MEA (ZO) 534, 3(3-0) S. Alt. yrs.* Current research and biological and physical processes structuring shallow and deep water benthic communities. Recent research on competition, predation, disturbance, succession, animal-sediment-flow interactions, life history tactics and experimental design in marine benthic biology. Student discussion of current issues and critique of recent papers. Levin

MEA (ZO) 624 Ecology of Fishes. *Preq.: BO (ZO) 360 or 560 or equivalent, 3(3-0) F.* Physiological ecology of fishes emphasizing energetics, production and adaptations to aquatic mediums. Ecological classification of fishes and theory of resource partitioning in freshwater, estuarine and marine realms. Miller

MEA (MAE) 663 Advanced Geophysical Fluid Mechanics. *Preq.: MAE 550 or equivalent, 3(3-0) S. Alt. yrs.* The principles of fluid mechanics are applied to geophysical systems. Special emphasis placed on the role of stable stratification on the flows in these systems. The generation, interaction, propagation and dissipation of internal gravity waves studied in detail. Other geophysically important flows also studied. Janowitz

MEA (MAE) 664, 665 Perturbation Method in Fluid Mechanics I, II. *Preqs.: MA 401, MAE 308, 3(3-0) F, S. Alt. yrs.* Basic theory and application of perturbation methods in fluid mechanics including: regular and singular perturbations, matching principles, method of strained coordinate, two variable expansion and applications to partial differential equations. Janowitz

MEA 674 Marine Geochemistry. *Preqs.: CH 331, MEA 571 or equivalent, 3(3-0) S. Alt. yrs.* A detailed examination of the chemical processes occurring in the marine environment. Topics discussed include: chemical evolution of the oceans, continental and submarine weathering, particle scavenging of reactive elements from the water, column, formation of biogenic and metalliferous deposits, sediment diagenesis and marine geochronology. DeMaster

MEA 693 Advanced Special Topics. *Preqs.: Grad. standing and CI. 1-3.* This course provides the opportunity for advanced graduate students to study in special problem areas in marine sciences. Various areas in the program may use this course concurrently in their areas. Graduate Staff

MEA 699 Research. *Preqs.: Grad. standing and consent of advisory committee. Credits Arranged. F, S.* Graduate Staff

Materials Science and Engineering

GRADUATE FACULTY

Professor J. J. Hren, Head

Professor H. Palmour III, Associate Department Head

Professor, A. A. Fahmy, Graduate Administrator

Professors: K. J. Bachmann, J. R. Beeler Jr., R. B. Benson Jr., H. Conrad, R. F. Davis, C. C. Koch, K. L. Moazed, J. Narayan, G. A. Rozgonyi, R. O. Scattergood, H. H. Stadelmaier; *Adjunct Professors:* G. Mayer, J. L. Routbort; *Professors Emeriti:* W. W. Austin, J. K. Magor, R. F. Stoops; *Associate Professor:* P. E. Russell; *Visiting Associate Professor:* J. C. Russ; *Adjunct Associate Professor:* I. Turlik; *Associate Professor Emeritus:* J. V. Hamme; *Assistant Professors:* C. M. Balik, N. A. El-Masry, J. T. Glass, A. I. Kingon; *Lecturer:* R. L. Porter

ASSOCIATE MEMBERS OF THE DEPARTMENT

Professors: J. A. Bailey, K. Havner, Y. Horie, G. Lucovsky, A. Reisman; *Associate Professor:* R. J. Nemanich

The Department of Materials Science and Engineering offers graduate programs leading to the degrees of Master of Science, Master of Materials Science and Engineering and Doctor of Philosophy. Students with appropriate backgrounds in engineering, chemistry or physics can be accommodated, although most students enter the program with degrees in a materials-related discipline. Financial aid is available on a competitive basis to qualified students.

Graduate students in materials engineering are involved with academic studies and research programs that focus on understanding the structure, structure modification and properties of materials. Included is the development of new or improved materials and advanced processing methods, which are critical links between the design and the realization of new systems. Materials and materials limitations pervade all of the engineering and high technology fields that are an integral part of our society. The challenges and opportunities for graduates in materials engineering are exceptional.

Research in the department comprises a wide range of programs that deal with physical, chemical and mechanical behavior involving both bulk and surface phenomena in metals, ceramics, polymers and composites. There are rapidly growing activities in the areas of microelectronic materials, advanced processing methods for metals and ceramics, non-equilibrium structures and surface modification processes. The research programs are supported by state-of-the-art facilities for preparation, processing and characterization of materials. An ion-beam microprobe, analytical scanning-transmission microscopy and VAX-based computer facility are among the recent acquisitions that support departmental research programs.

The faculty in materials science and engineering offers experience in all of the basic materials-related disciplines. Each student's program is designed to provide the appropriate balance of academic and research work consistent with that student's background and career objectives.

A brochure describing the department's graduate programs, research interests and faculty members is available upon request.

SELECTED ADVANCED UNDERGRADUATE COURSES

MAT 400 **Metallic Materials in Engineering Design.** *Preq.: MAT 200 or 201. 3(3-0) F,S.*

MAT 410 Computer Applications for Materials Engineering. *Preqs.: CSC 111; Coreq.: MAT 330. 3(3-0) F.*

MAT 423 Materials Factors in Design. *Preq.: MAT 450. 3(2-3) F.*

MAT 431 Physical Metallurgy I. *Preqs.: MAT 321, 450. 4(4-0) F.*

MAT 432 Physical Metallurgy II. *Preq.: MAT 431. 3(3-0) S.*

MAT 435 Physical Ceramics I. *Preqs.: MAT 321, MAT 434. 3(3-0) S.*

MAT 436 Physical Ceramics II. *Preq.: MAT 435. 3(3-0) S.*

MAT 450 Mechanical Properties of Materials. *Preq.: MAT 325 and 330; MAE 314. 3(3-0) F.*

MAT 460 Microelectronic Materials. *Preqs.: MAT 332, ECE 441. 3(3-0) S.*

FOR GRADUATES AND ADVANCED UNDERGRADUATES

MAT 500 Modern Concepts in Materials Science. *Preq.: Grad. standing. 3(3-0) F.* Fundamentals of structure, structure modification and properties of materials with emphasis on structure-property relationships and the modern theory of solids.

MAT 501 Diffusion and Mass Transport Processes in Solids. *Preq.: CI. 3(3-0) F.* Interatomic forces and crystal structure, basic concepts in diffusion theory, diffusion and mass transport in metals and alloys, semiconductors, ionic crystals (ceramics) and amorphous materials. Diffusion along dislocations and grain boundaries, surface and interface diffusion, electromigration and thermomigration, concentration-enhanced diffusion, transient diffusion, stress-induced diffusion, mass and heat transport during rapid solidification, radiation damage and defect diffusion.

MAT 502 Defects in Solids. *Preq.: CI. 3(3-0) Sum.* Defect structure in ionic, covalent and metallic solids of either a crystalline or an amorphous nature. Effects of defects on the mechanical, electrical, magnetic, chemical and optical properties of solids. Computer software is provided for the exploration of defect interactions via computer simulation.

MAT 504 Electrical, Optical and Magnetic Properties of Materials. *Preqs.: MAT 500, 510. 3(3-0) S.* Electron theory of materials, band theory; electrical behavior of metals, semiconductors, dielectrics and noncrystalline materials; theory of optical behavior and applications; foundations of magnetic properties and applications of ferrites and permanent magnetic materials.

MAT 505 Mechanical Behavior of Engineering Materials. *Preqs.: MAT 450, MAT 502. 3(3-0) S.* Both fundamental and engineering aspects of mechanical behavior of materials covered. Elasticity, plasticity and dislocation theory concepts used to describe phenomenological behavior and micromechanical mechanisms. Topics covered include strengthening mechanisms in crystals, high-temperature deformation, fracture mechanics, fracture toughening mechanisms and cyclic deformation. Various aspects of deformation of noncrystalline solids also included.

MAT 506 Phase Transformations and Kinetics. *Preqs.: MAT 500, 510. 3(3-0) F.* Homogeneous and heterogeneous nucleation, spinodal decomposition, interface and diffusion-controlled growth, formal theory of transformation kinetics, growth of crystals from the vapor, precipitation, coarsening, order-disorder, and martensitic transformations.

MAT(CH) 507 Chemical Concepts in Materials Science and Engineering. *Preq.: CI. 3(3-0) F.* Structure, symmetry and chemical bonding; spectroscopic methods and their utilization in trace analysis and pollution control; phase equilibria, crystal growth and materials purification; vapor phase equilibria and the kinetics of chemical reactions and

transport; electrochemical thermodynamics and kinetics with applications to batteries, solar cells, electrorefinement, plating and corrosion processes.

MAT 508 Thermodynamics of Materials. *Preq.: MAT 301 or equivalent. 3(3-0) F.* A review of the first and second laws of thermodynamics, equilibrium and irreversible processes, open and closed systems, partition functions and particle distribution functions. Applications include extension of the thermodynamic potentials to situations where electrical, magnetic and stress fields are present, heat capacity of crystals, electron gas in metals, solution models, binary phase diagrams and rubber elasticity in polymers.

MAT 510 Elements of Crystallography and Diffraction. *Preq.: MAT 411. 3(3-0) F.* Crystal symmetry, lattices and space groups; elementary diffraction by crystalline matter; experimental methods of x-ray diffraction.

MAT 511 Stereology and Image Analysis. *Preq.: Grad. standing. 3(3-0) S. Alt. yrs.* Development of principles and their practical application to measurement of images from microscopy (primarily materials) to describe three-dimensional structure of specimens viewed in transverse sections or projection. Includes basic statistics, manual and automatic (computerized) image analysis methods. Basic stereological parameters (volume fraction, surface density, curvature) plus object size and shape parameters, fractal and stereoscopic description of surfaces.

MAT 512 Scanning Electron Microscopy. *Preq.: Grad. standing. 3(3-0) F.* Electron optics, sources and detectors. Beam specimen interactions, secondary and backscattered electrons, EDS and WDS. Resolution limits, experimental conditions, related techniques, beam-induced damage and materials modification.

MAT 515 Fundamentals of Transmission Electron Microscopy. *Preq.: MAT 510 or equivalent. 3(2-3) S.* Electron optics, electron solid interactions, basic electronic diffraction, contrast from amorphous materials, diffraction contrast, defect characterization, introduction to analytical electron microscopy. Laboratory experiments illustrating these concepts.

MAT (NE) 525 Nuclear Materials. *3(3-0) F.* (See nuclear engineering.)

MAT 529 Properties of High Temperature Materials. *Preqs.: MAT 201 and MAT 301. 3(3-0) S.* Effects of temperature on the physical, mechanical and chemical properties of inorganic materials; relationships between microstructure and high temperature properties; applications of ceramics, metals and composites at elevated temperatures.

MAT (MAE) 531 Materials Processing by Deformation. *3(3-0) F.* (See mechanical and aerospace engineering.)

MAT (MAE) 532 Fundamentals of Metal Machining Theory. *3(3-0) S.* (See mechanical and aerospace engineering.)

MAT 533 Advanced Ceramic Engineering Design. *Preq.: MAT 417. 3(2-3) F.* Advanced studies in analysis and design of ceramic products, processes and systems leading to original solutions of current industrial problems and the development of new concepts of manufacturing.

MAT 540 Glass Technology. *Preq.: MAT 435. 3(3-0) F.* Fundamentals of glass manufacture including compositions, properties and application of the principal types of commercial glasses.

MAT 541 Principles of Corrosion. *Preqs.: MAT 201 and CH 431 or MAT 301. 3(2-3) F.* The fundamentals of metallic corrosion and passivity. The electro-chemical nature of corrosive attack, basic forms of corrosion, corrosion rate factors, methods of corrosion protection. Laboratory work included.

MAT 556 Composite Materials. *Preq.: MAT 450. 3(3-0) F.* Basic principles underlying the properties of composite materials as related to properties of the individual constituents and their interactions. Emphasis on the design of composite systems to yield desired combinations of properties.

MAT 560 Materials Science and Processing of Semiconductor Devices. *Preq.: MAT 460. 3(3-0) S. Alt. yrs.* Ion implantation and doping of semiconductor devices, thin films and epitaxy, silicides, ohmic contacts and interconnection metallurgy, oxidation and nitridation, gettering of impurities and dopant segregation phenomena, electromigration, electronic packaging materials science, advanced device concepts.

MAT (TC) 561 Organic Chemistry of Polymers. *3(3-0) S.* (See textile chemistry.)

MAT (TC) 562 Physical Chemistry of High Polymers—Bulk Properties. *3(3-0) F. Alt. yrs.* (See textile chemistry.)

MAT (NE) 573 Computer Experiments in Materials and Nuclear Engineering. *Preq.: Advanced undergrad. standing. 3(3-0) S.* Monte Carlo and dynamical computer experiments covered from the standpoint of how to design and use them in materials and nuclear engineering work.

MAT 595 Advanced Materials Experiments. *Preq.: Sr. or grad. standing. 1-3.* Advanced engineering principles applied to a specific experimental project dealing with materials. A seminar period provided and a written report required.

FOR GRADUATES ONLY

MAT 610 Advanced Crystallography and Diffraction. *Preq.: MAT 510. 3(3-0) F.* Symmetry in crystals and space group determination. Kinematic and dynamical scattering theories. Experimental methods involving single crystals. Image formation in x-ray topography and electron microscopy. Disorder and defects. Methods of crystal structure analysis. Residual stresses and preferred orientation in polycrystals.

MAT 612 Advanced Scanning Electron Microscopy and Surface Analysis. *Preq.: MAT 512 or equivalent. 3(3-0) S. Alt. yrs.* Beam specimen interactions, voltage contrast, electron spectrometers, stroboscopy, EBIC, cathodoluminescence, channeling, backscattering, magnetic contrast, vacuum science, instrumentation, ion sputtering, Auger electron spectroscopy, SIMS, quantitative EDS, ESCA, FIM, STM.

MAT 621 Theory and Structure of Amorphous Materials. *Preq.: MAT 500. 3(3-0) S.* Bond types and structure of amorphous solids, relations of bond types and structure to flow mechanisms, electrical, optical and thermal properties.

MAT 622 Theory and Structure of Ceramic Materials. *Preq.: MAT 500. 3(3-0) F.* Electrical and optical properties of non-conducting materials, ferro-electric behavior and materials parameters, magnetic properties of non-metallics, semi-conducting materials.

MAT 623 Theory and Structure of Metallic Materials. *Preq.: MAT 500. 3(3-0) F.* The metallic state, its atomic and electronic structure. Electron theory of metals and alloys. Advanced methods of determining electronic structure in metallic materials. Solid solutions and intermediate phases, superconducting and magnetic alloys.

MAT 630 Phase Transformation in Materials II. *Preqs.: MAT 510, 530, 550. 3(3-0) F.* Formal theories of solid-solid transformations, transformation mechanisms, transformation morphologies.

MAT 631 Thin Film and Coating Science and Technology I. *Preq.: MAT 500. 3(3-0) F.* Vacuum science and technology including gas kinetics, gas flow calculations, system design and the use of various pumps, materials and components. Atomistics of solid surfaces. Nucleation and growth of films and coatings.

MAT 632 Thin Film and Coating Science and Technology II. *Preq.: MAT 631. 3(3-0) S. Alt yrs.* Techniques for thin films and coatings deposition and their applications. Interfaces, adhesion and surface modification. Artificially structured and chemically modulated layered materials. Pseudomorphic structures. Characterization of thin films and coatings.

MAT 633 Advanced Mechanical Properties of Materials. *Preq.: MAT 630. 3(3-0) F.* The theories of yield strength, work hardening, creep, fracture and fatigue of crystalline materials developed in terms of dislocation theory.

MAT 660 Defects, Diffusion and Ion Implantation in Semiconductors. *Preq.: MAT 501 or equivalent. 3(3-0) F. Alt yrs.* Thermodynamics of vacancies and interstitials, defect complexes, electronic defects, defect annealing processes, self diffusion, dopant and impurity diffusion, substitutional/interstitial diffusion, diffusion in amorphous solids, electro-transport, fundamentals of ion-solid interactions, atomic structure of defects, damage annealing processes, supersaturated alloys, laser annealing, ion beam mixing phenomena.

MAT (CH, TC) 662 Physical Chemistry of High Polymers—Solution Properties. *3(3-0) S. Alt. yrs.* (See textile chemistry.)

MAT 691, 692 Advanced Topics in Materials Science and Engineering. *Preq.: Grad. standing. 1-3.* Special studies of advanced topics in materials engineering.

MAT 695 Materials Science and Engineering Seminar. *1(1-0) F,S.* Reports and discussion of special topics in materials engineering and allied fields.

MAT 699 Materials Science and Engineering Research. *Credits Arranged.* Independent investigation of an appropriate research problem. A report on this investigation required as a graduate thesis.

Mathematics

GRADUATE FACULTY

Professor R. H. Martin Jr., *Head*

Associate Professor: J. E. Franke, *Graduate Administrator*

Professors: J. W. Bishir, E. E. Burniston, S. L. Campbell, R. E. Chandler, E. N. Chukwu, L. O. Chung, J. M. A. Danby, J. C. Dunn, M. J. Evans, A. Fauntleroy, R. O. Fulp, R. E. Hartwig, C. T. Kelley, K. Koh, J. Luh, J. A. Marlin, L. B. Martin Jr., C. D. Meyer, N. K. Nichols, C. V. Pao, E. L. Peterson, R. J. Plemmons, M. S. Putcha, H. Sagan, J. F. Selgrade, M. Shearer, C. E. Siewert, M. F. Singer, E. L. Stitzinger, R. E. White; *Professors Emeriti:* R. C. Bullock, J. M. Clarkson, W. J. Harrington, J. Levine, H. M. Nahikian, P. A. Nickel, H. V. Park, N. J. Rose, R. A. Struble, J. B. Wilson; *Associate Professors:* M. T. Chu, J. D. Cohen, G. D. Faulkner, D. E. Garoutte, T. J. Lada, D. M. Latch, L. K. Norris, L. B. Page, R. T. Ramsay, J. Rodriguez, S. Schecter, R. Silber, J. W. Silverstein, D. F. Ullrich; *Assistant Professors:* H. J. Charlton, R. Haas, D. J. Hansen, A. G. Helminck, A. Kheyfets, K. C. Misra, B. Moro, S. O. Paur, J. L. Rulla, S. J. Wright

The Department of Mathematics offers programs leading to the degrees of Master of Science and Doctor of Philosophy with a major in either mathematics or applied mathematics.

Applicants for admission should have an undergraduate degree in mathematics or its equivalent. This should include a year of mathematical analysis (or advanced calculus) and a year of modern algebra, including linear algebra. All applicants are advised to take the Graduate Record Examination including the Advanced Test in Mathematics.

A number of teaching assistantships are available. A student carrying a half-time assistantship is allowed to carry a course load of nine semester hours.

The requirements for the Master of Science degree include 36 semester hours of approved credits and a comprehensive examination. A master's project for 3 hours credit is required. Foreign languages are not required for the master's degree.

There is no prescribed minimum number of courses for the degree of Doctor of Philosophy. Normally a student will take approximately 60 semester hours of course credits including certain core courses in algebra, analysis and applied mathematics. Independent reading and participation in seminars constitute an indispensable part of the doctoral program.

All doctoral students are required to have a reading knowledge of one modern foreign language. Comprehensive examinations are also required. These consist of a written examination designed to test basic knowledge and oral and written examinations on material related to the field of proposed thesis work.

The heart of the doctoral program is the dissertation. It must be original research resulting in a significant contribution in some area of mathematics or its applications and should be worthy of publication in the current literature. The doctoral dissertation must be defended at the final oral examination.

Computational mathematics (CMA) is a plan of study which is attached to the graduate program in applied mathematics. Its emphasis is on numerical analysis with components of computer science and applications to engineering and the sciences. There is a rich collection of graduate-level numerical analysis course work and over 15 mathematics faculty involved in CMA. Their expertise includes numerical solution of ordinary and partial differential equations, optimization, structures, symbolic computations, integral equations, transport theory, computational fluids, numerical linear algebra, numerical control and probabilistic computations. Many of the faculty have current research projects dealing with parallel algorithms and their implementation on advanced computing architectures. Computing facilities include the state-of-the-art multiprocessing/vector Alliant FX/40 and Cray Y-MP supercomputers, and the multiprocessing Sequent computer. Prospective CMA students should have additional undergraduate course work, or equivalent experience, in differential equations, numerical analysis with FORTRAN and a year of computer science (computer organization, assembler language and data structures).

A detailed statement of requirements for graduate degrees is available on request from the graduate administrator.

SELECTED ADVANCED UNDERGRADUATE COURSES

MA 401 Applied Differential Equations II. *Preq.: MA 301. Credit for both MA 401 and MA 501 will not be given. 3(3-0) F,S,Sum.*

MA 403 Introduction to Modern Algebra. *Preq.: MA 225. 3(3-0) F,S,Sum.*

MA 405 Introduction to Linear Algebra and Matrices. *Preq.: One yr. of calculus. 3(3-0) F,S,Sum.*

MA 407 Introduction to Modern Algebra for Mathematics Majors. *Preq.: MA 225. Credit is not allowed for MA 403 and MA 403M. 3(3-0) F,S.*

MA 408 Foundations of Euclidean Geometry. *Preq.: MA 225 or MA (CSC) 322. 3(3-0) S.*

MA 410 Theory of Numbers. *Preq.: One yr. of calculus. 3(3-0) S.*

MA 414 Introduction to Differential Geometry. *Preqs.: MA 202 and 405. 3(3-0) S.*

MA (CSC) 416 Introduction to Combinatorics. *Preq.: MA 403 or CSC 322. 3(3-0) F.*

MA 421 Introduction to Probability. *Preq.: One yr. of calculus. 3(3-0) F,S,Sum.*

MA 425 Mathematical Analysis I. *Preq.: MA 202 (MA 403 desirable). 3(3-0) F,S.*

MA 426 Mathematical Analysis II. *Preqs.: MA 425 and MA 405. 3(3-0) S.*

MA (CSC) 427 Introduction to Numerical Analysis I. *Preqs.: MA 301 and a programming language proficiency. 3(3-0) F.*

MA (CSC) 428 Introduction to Numerical Analysis II. *Preqs.: MA 405 and programming language proficiency. 3(3-0) S.*

MA 430 Mathematical Models in the Physical Sciences. *Preqs.: MA 301 and MA 405. 3(3-0) F.*

MA 432 Mathematical Models in Life Sciences and Social Sciences. *Preqs.: MA 301, MA 405; Coreq.: MA 421 or ST 371. 3(3-0) S.*

MA 433 History of Mathematics. *Preq.: One yr. of calculus. 3(3-0) F,S.*

FOR GRADUATES AND ADVANCED UNDERGRADUATES

MA 501 Advanced Mathematics for Engineers and Scientists I. *Preq.: MA 301 or equivalent. Credit for this course and MA 401 is not allowed. 3(3-0) F,S,Sum.* Survey of mathematical methods for engineers and scientists. Ordinary differential equations and Green's functions; partial differential equations and separation of variables; special functions, Fourier series. Applications to engineering and science. This course cannot be taken for credit by mathematics majors.

MA 502 Advanced Mathematics for Engineers and Scientists II. *Preq.: MA 301 or equivalent. Any student receiving credit for MA 502 may receive credit for, at most, one of the following: MA 405, MA 512, MA 513. 3(3-0) F,S,Sum.* Determinants and matrices; line and surface integrals, integral theorems; complex integrals and residues; distribution functions of probability. This course cannot be taken for credit by mathematics majors.

MA (IE, OR) 505 Linear Programming. *3(3-0) F,S.* (See industrial engineering.)

MA 507 Analysis for Secondary Teachers. *Preq.: Grad. standing. 3(3-0) F,Sum. Alt. yrs.* A course designed to update and broaden the secondary teacher's capability and point-of-view with respect to topics in analysis. Historical development, logical refinement and applications of concepts such as limits, continuity, differentiation and integration. This course may be taken for graduate credit for certificate renewal by secondary school teachers. Credit towards a graduate degree may be allowed only for students in mathematics education.

MA 508 Geometry for Secondary Teachers. *Preq.: Grad. standing. 3(3-0) S, Sum. Alt. yrs.* A course designed to study topics in geometry of concern to secondary teachers in their work and to provide background and enrichment. Various approaches to the study of geometry, including vector geometry, transformational geometry and axiomatics. This course may be taken for graduate credit and for certificate renewal by secondary school teachers. Credit towards a graduate degree may be allowed only for students in mathematics education.

MA 509 Abstract Algebra for Secondary Teachers. *Preq.: Grad. standing. 3(3-0) F, Sum. Alt. yrs.* A course designed to investigate from an advanced viewpoint topics in algebra from the high school curriculum. Theory of equations, polynomial rings, rational functions and elementary number theory. This course may be taken for graduate credit for certificate renewal by secondary school teachers. Credit towards a graduate degree may be allowed only for students in mathematics education.

MA 510 Selected Topics in Mathematics for Secondary Teachers. *Preq.: Grad. standing. 3(3-0) S, Sum. Alt. yrs.* A course designed to cover various topics in mathematics of concern to secondary teachers. Topics selected from areas such as mathematics of finance, probability, statistics, linear programming and theory of games, intuitive topology, recreational math, computers and applications of mathematics. This course may be taken for graduate credit for certification renewal by secondary school teachers. Credit towards a graduate degree may be allowed only for students in mathematics education.

MA 511 Advanced Calculus I. *Preq.: MA 301. May not be taken for credit by undergrad. mathematics majors. 3(3-0) F, S, Sum.* Fundamental theorems on continuous functions; convergence theory of sequences, series and integrals; the Riemann integral.

MA 512 Advanced Calculus II. *Preq.: MA 301. 3(3-0) F, S, Sum.* General theorems of partial differentiation; implicit function theorems; vector calculus in 3-space; line and surface integrals; classical integral theorems.

MA 513 Introduction to Complex Variables. *Preq.: MA 242. 3(3-0) F, S, Sum.* Operations with complex numbers, derivatives, analytic functions, integrals, definitions and properties of elementary functions, multivalued functions, power series, residue theory and applications, conformal mapping.

MA 514 Methods of Applied Mathematics. *Preq.: MA 511 or 425. 3(3-0) S.* Introduction to integral equations, the calculus of variations and difference equations.

MA 515 Real Analysis. *Preq.: MA 426. 3(3-0) S.* An introduction to advanced analysis. Measurable sets and functions; Lebesgue measure; Riemann and Lebesgue integrals; Fatou's lemma; monotone and Lebesgue convergence theorems; differentiation and integration; functions of bounded variation; absolute continuity; L^p spaces; Holder and Minkowski inequalities; convergence and completeness; approximation by steps and continuous functions.

MA 517 Introduction to Topology. *Preq.: MA 426. 3(3-0) F.* Sets and functions, metric spaces, topological spaces, compactness, separation, connectedness.

MA 518 Calculus on Manifolds. *Preq.: MA 426. 3(3-0) S.* Calculus of several variables from a modern viewpoint. Differential and integral calculus of several variables, vector functions, integration of manifolds, Stokes' and Green's theorems, vector analysis.

MA 520 Linear Algebra. *Preq.: MA 405. 3(3-0) F.* Vector spaces, linear mappings and matrices, determinants, inner product spaces, bilinear and quadratic forms, canonical forms, spectral theorem.

MA 521 Fundamentals of Modern Algebra. *Preqs.: MA 407 and 520. 3(3-0) S.* Groups, normal subgroups, quotient groups, Cayley's theorem, Sylow's theorem. Rings, ideals and quotient rings, polynomial rings. Fields, extension fields, elements of Galois theory.

MA 524 Mathematical Methods in the Physical Sciences I. *Preqs.: MA 405, 511 and either MA 401 or 501. 3(3-0) F.* Green's functions and two-point boundary value problems; elementary theory of distributions; generalized Green's functions. Finite and infinite dimensional inner product spaces; Hilbert spaces; completely continuous operators; integral equations; the Fredholm alternative; eigenfunction expansions; applications to potential theory. Nonsingular and singular Sturm-Liouville problems; Weil's theorem.

MA 525 Mathematical Methods in the Physical Sciences II. *Preq.: MA 524. 3(3-0) S.* Distribution theory in n -space; Fourier transforms; partial differential equations, generalized solutions, fundamental solutions, Cauchy problem, wave and heat equations, well-set problems. Laplace's equation, the Dirichlet and Neumann problems, integral equations of potential theory, Green's functions, eigenfunction expansions.

MA (CSC) 529 Numerical Analysis I. *Preqs.: MA 405, MA 511, high level computer language. 3(3-0) F.* For students in the engineering, physical and mathematical sciences. Illustrates algorithm behavior and applicability. Topics include the effect of roundoff errors, systems of linear equations and direct methods, least squares via Givens and Householder transformations, iterative methods, convergence for SOR with symmetric positive definite matrices, the conjugate gradient method, eigenvalue problems, Newton's method, initial value problems and partial differential equations.

MA (CSC) 530 Numerical Analysis II. *Preq.: MA 529. 3(3-0) S.* Topics include approximation, quadrature, Newton's method, roots of polynomials, minimization problems, ordinary differential equations with boundary conditions and variational methods.

MA (E, OR) 531 Dynamic Systems and Multivariable Control I. *3(3-0) F.* (See operations research.)

MA 532 Theory of Ordinary Differential Equations. *Preqs.: MA 301, 405, advanced calculus. 3(3-0) S.* Existence and uniqueness theorems, systems of linear equations, fundamental matrices, matrix exponential, nonlinear systems, plane autonomous systems, stability theory.

MA 534 Introduction to Partial Differential Equations. *Preqs.: MA 425 or MA 511, MA 301. 3(3-0) F.* Theory of characteristics and classification of second order equations, existence, uniqueness and representation of solutions for the wave equation, Dirichlet and Neumann boundary-value problems for the Laplace equation, potential theory in two and higher dimensional domains, mean-value theorem and the maximum principle, Green's identities, initial boundary-value problems of heat equation and wave equation. Maximum principle of parabolic equation, method of eigenfunction expansions, Fourier series and Fourier transforms.

MA (ST) 541 Theory of Probability I. *Preq.: MA 425 or 511. 3(3-0) F, Sum.* Axioms, combinatorial analysis, conditional probability, independence, random variables, expectation, special discrete and continuous distributions, probability and moment generating functions, central limit theorem, laws of large numbers, branching processes, recurrent events, random walk.

MA (ST) 542 Introduction to Stochastic Processes. *3(3-0) S.* (See statistics.)

MA 545 Set Theory and Foundations of Mathematics. *Preq.: MA 407. 3(3-0) S.* Logic and the axiomatic approach, the Zermelo-Fraenkel axioms and other systems, algebra of sets and order relations, equivalents of the Axiom of Choice, one-to-one correspondences, cardinal and ordinal numbers, the Continuum Hypothesis.

MA (PY) 555 Mathematical Introduction to Celestial Mechanics. *Preq.: MA 301. 3(3-0) F.* Central orbits, N -body problem, 3-body problem, Hamilton-Jacobi theory, perturbation theory, applications to motion of celestial bodies.

MA (PY) 556 Orbital Mechanics. *Preqs.: MA 301, 405, knowledge of elementary mechanics and computer programming. 3(3-0) S.* Keplerian motion, iterative solutions, numerical integration, differential corrections and space navigation, elements of probability, least squares, sequential estimation, Kalman filter.

MA (BMA, ST) 571 Biomathematics I. *3(3-0) F.* (See biomathematics.)

MA (BMA, ST) 572 Biomathematics II. *3(3-0) S.* (See biomathematics.)

MA 581 Special Topics. *Preq.: Consent of department. 1-6 F,S.*

MA (CSC) 583 Numerical Solution of Ordinary Differential Equations. *Preq.: MA 512. 3(3-0) S.* Numerical methods for initial value problems including predictor-corrector, Runge-Kutta, hybrid and extrapolation methods; stiff systems; shooting methods for two-point boundary value problems; weak, absolute and relative stability results.

MA (CSC) 584 Numerical Solution of Partial Differential Equations—Finite Difference Methods. *Preqs.: MA 501; knowledge of a high level programming language. 3(3-0) F.* A survey of finite difference methods for partial differential equations including elliptic, parabolic and hyperbolic PDE's. Both linear and nonlinear problems are considered. Theoretical foundations are described; however, emphasis is placed on algorithm design and implementation.

MA (CSC, OR) 585 Graph Theory. *3(3-0) F.* (See computer science.)

MA (IE, OR) 586 Network Flows. *3(2-2) S.* (See industrial engineering.)

MA (CSC) 587 Numerical Solution of Partial Differential Equations—Finite Element Method. *Preqs.: MA 501; knowledge of a high level programming language. 3(3-0) S.* An introduction to the finite element method. Applications to both linear and nonlinear elliptic and parabolic partial differential equations. Theoretical foundations described; however, emphasis placed on algorithm design and implementation.

FOR GRADUATES ONLY

MA 600 Advanced Differential Equations I. *Preqs.: MA 513, 518, 520. 3(3-0) F. Alt. yrs.* Analytical theory of ordinary differential equations, stability theory, perturbations, asymptotic behavior, nonlinear oscillations.

MA 601 Advanced Differential Equations II. *Preq.: MA 600. 3(3-0) S. Alt. yrs.* Qualitative theory of ordinary differential equations, general properties of dynamical systems, limit sets, integral invariants, global theory.

MA 602 Partial Differential Equations I. *Preqs.: MA 426, 520, 532 or 600. 3(3-0) F. Alt. yrs.* Linear second order parabolic, elliptic and hyperbolic equations, initial and boundary value problems, strong maximum principles, variational and approximation methods, iterative methods for boundary value problems.

MA 603 Partial Differential Equations II. *Preq.: MA 602. 3(3-0) S. Alt. yrs.* Nonlinear initial and boundary value problems, existence and uniqueness theorems, qualitative analysis and stability theory, comparison and approximation methods, numerical methods and error analysis.

MA 604 Topology. *Preqs.: MA 515, 520. 3(3-0) S.* Topological spaces: separation axioms, compactness, connectedness, local topological properties; continuous mappings and convergence; product and quotient spaces; compactification; homotopy equivalence of mappings, fundamental groups, covering spaces, universal coverings, deck transformations.

MA (ST, OR) 606 Nonlinear Programming. *3(3-0) S.* (See statistics.)

MA (NE) 607 Exact and Approximate Solutions in Particle Transport Theory. *Preq.: MA 501 or MA 511. 3(3-0) S.* The method of elementary solutions used to solve exactly basic problems in neutron-transport theory and related topics. In addition, the F_N method developed and used to establish concise approximate solutions in the realm of particle transport theory.

MA (BMA, OR, ST) 610 Stochastic Modeling. *3(3-0) S. Alt. yrs.* (See biomathematics.)

MA 611 Analytic Function Theory I. *Preq.: MA 426. 3(3-0) F.* A rigorous introduction to the theory of functions of a complex variable. The complex plane, functions, Mobius transformations, the exponential and logarithmic functions, trigonometric functions, infinite series, integration in the complex plane, Cauchy's theorem and its consequences.

MA 612 Analytic Function Theory II. *Preq.: MA 611. 3(3-0) S.* A continuation of MA 611. Taylor and Laurent series. The residue theorem, the argument principle, harmonic functions and the Dirichlet problem, analytic continuation and the monodromy theorem, entire and meromorphic functions, the Weierstrass product representation and the Mittag-Leffler partial fraction representation, special functions, conformal mapping and the Picard theorem.

MA 613 Techniques of Complex Analysis. *Preq.: MA 513 or 611. 3(3-0) S.* A course dealing with the applications of complex analysis to mathematical problems in physical science in the setting of the potential equation and other partial differential equations: contour integrals, special functions of mathematical physics from the line integral point of view, solution of problems in potential theory, asymptotic methods including WKB and Wiener-Hopf techniques.

MA (OR) 614 Integer Programming. *3(3-0) S. Alt. yrs.* (See operations research.)

MA (ST) 617, 618 Measure Theory and Advanced Probability. *3(3-0) F, S.* (See statistics.)

MA 620 Modern Algebra I. *Preq.: MA 521. 3(3-0) F. Alt. yrs.* A study of groups, rings and modules. Elements of homology. Polynomials, Noetherian rings, Algebraic extensions, Galois theory.

MA 621 Modern Algebra II. *Preq.: MA 620. 3(3-0) S. Alt. yrs.* A study of linear maps, bilinear forms, representations, multilinear products, semisimplicity and the representation of finite groups.

MA 622 Linear Transformations and Matrix Theory. *Preq.: MA 405. 3(3-0) F.* Vector spaces, linear transformations and matrices, orthogonality, orthogonal transformations with emphasis on rotations and reflections, matrix norms, projectors, least squares, generalized inverses, definite matrices, singular values.

MA 623 Theory of Matrices and Applications. *Preq.: MA 520 or 622. 3(3-0) S.* Canonical forms, functions of matrices, variational methods, perturbation theory, numerical methods, nonnegative matrices, applications to differential equations, Markov chains.

MA 626 Algebraic Topology. *Preq.: MA 605. 3(3-0) S. Alt. yrs.* Simplicial and singular homology and cohomology, the Eilenberg-Steenrod axioms, duality, cohomology operations; higher homotopy groups, Hurewicz homomorphisms.

MA (OR) 629 Vector Space Methods in System Optimization. *3(3-0) F.* (See operations research.)

MA (E, OR) 631 Dynamic Systems and Multivariable Control II. *3(3-0) S. Alt. yrs.* (See operations research.)

MA 632 Operational Mathematics I. *Preq.: MA 513 or 611. 3(3-0) F.* Laplace transforms with theory and application to ordinary and partial differential equations arising from problems in engineering and physics.

MA 633 Operational Mathematics II. *Preq.: MA 632. 3(3-0) S.* Extended development of the Laplace and Fourier transforms and their application to the solution of ordinary and partial differential equations, integral equations and difference equations; Z-transforms, other infinite and finite transforms and their applications.

MA 637 Differentiable Manifolds. *Preqs.: MA 405, 521; Coreq.: MA 604. 3(3-0) F. Alt. yrs.* An introduction to the topology and geometry of differentiable manifolds, multilinear algebra, exterior differential forms, differentiable manifolds, theory of connexions, Riemannian manifolds.

MA 647 Functional Analysis I. *Preq.: MA 515. 3(3-0) F. Alt. yrs.* Banach spaces; linear functionals; linear operators, uniform boundedness, open mapping and closed graph theorems; dual spaces; weak topologies.

MA 648 Functional Analysis II. *Preq.: MA 647. 3(3-0) S. Alt. yrs.* Advanced topics in functional analysis such as linear topological spaces; Banach algebra, spectral theory and abstract measure theory and integration.

MA 661 Differential Geometry and Tensor Analysis I. *Preq.: MA 426 or 512. 3(3-0) F. Alt. yrs.* Concepts of classical and modern differential geometry presented from the point of view of tensor analysis and differential forms. Topics to include: theory of curves, tensor analysis and differential forms, intrinsic geometry of surfaces, Riemannian geometry.

MA 662 Differential Geometry and Tensor Analysis II. *Preq.: MA 661. 3(3-0) S. Alt. yrs.* Continuation of MA 661.

MA (CSC) 672 Advanced Numerical Linear Algebra. *Preq.: MA 529. 3(3-0) S.* Mathematical and numerical investigation of direct, iterative and semi-iterative methods for the solution of linear systems. Singular algebraic systems and least squares computations. Methods for the calculation of eigenvalues and eigenvectors presented. Careful mathematical analysis of these techniques given.

MA (CSC) 673 Parallel Algorithms and Scientific Computation. *Preq.: MA 529. S.* Multiprocessing and supercomputer architectures including Alliant FX/8, IBM 3090 VF-600, CRAY XMP-48, Intel iPCS and BBN Butterfly. The implementation of standard numerical linear algebra algorithms on vector and multiprocessing computers. Portability of codes from one computer to another. Typical applications to science and engineering.

MA (CSC) 674 Nonlinear Equations and Unconstrained Optimization. *Preq.: MA 529. 3(3-0) S. Alt. yrs.* Newton's method and Quasi-Newton methods for nonlinear equations and optimization problems, globally convergent extensions, methods for sparse problems, applications to differential equations, integral equations and general minimization problems. Methods appropriate for boundary value problems.

MA 681 Special Topics in Real Analysis. 1-6.

MA 682 Special Topics in Complex Analysis. 1-6.

MA 683 Special Topics in Algebra. 1-6.

MA 684 Special Topics in Combinatorial Analysis. 1-6.

MA 685 Special Topics in Numerical Analysis. 1-6.

MA 686 Special Topics in Topology. 1-6.

MA 687 Special Topics in Geometry. 1-6.

MA 688 Special Topics in Differential Equations. 1-6.

MA 689 Special Topics in Applied Mathematics. 1-6.

The subject matter in the special topics courses varies from year to year. The topics and instructors are announced well in advance by the department.

MA (IE, OR) 692 Special Topics in Mathematical Programming. 3(3-0) F,S,Sum. (See industrial engineering.)

MA 697 Master's Project. 3(3-0) F,S,Sum. Investigation of some topic in mathematics to a deeper and broader extent than typically done in a classroom situation. For the applied mathematics student the topic usually consists of a realistic application of mathematics to the student's minor area. A written and oral report on the project required.

MA 699 Research. Credits Arranged. Individual research in mathematics.

Mathematics and Science Education

For a listing of graduate faculty and departmental information, see mathematics and science education under education.

Mechanical and Aerospace Engineering

GRADUATE FACULTY

Professor J. A. Bailey, Head

Professor J. N. Perkins, Associate Department Head (Aerospace Engineering)

Professor J. A. Edwards, Associate Department Head (Mechanical Engineering)

Professor J. C. Mulligan, Graduate Administrator

Professors: E. M. Afify, F. R. DeJarnette, T. A. Dow, W. C. Griffith, F. D. Hart, H. A. Hassan, T. H. Hodgson, C. J. Maday, M. N. Ozisik, L. H. Royster, F. O. Smetana, F. Y. Sorrell, J. S. Strenkowski, C. F. Zorowski; *Visiting Professor:* M. M. Fikry; *Adjunct Professors:* R. L. Bradow, C. T. Crowe, D. E. Klett, E. R. McClure, R. A. Whisnant; *Professors Emeriti:* R. A. Burton, M. H. Clayton, J. S. Doolittle, B. H. Garcia Jr., F. J. Hale, J. K. Whitfield, J. Woodburn; *Associate Professors:* M. A. Boles, A. C. Eberhardt, H. M. Eckerlin, R. R. Johnson, R. F. Keltie, C. Kleinstreuer, J. W. Leach, D. S. McRae, R. T. Nagel, S. Torquato; *Adjunct Associate Professors:* J. P. Archie Jr., R. W. Barnwell, J. F. Campbell, P. B. Corson, D. L. Dwoyer, R. M. Hall, K. R. Iyer, D. W. Lee, D. L. Margolis, H. Singh, J. S. Stewart; *Assistant Professors:* G. V. Candler, J. W. David, J. W. Eischen, R. D. Gould, E. C. Klang, P. I. H. Ro, L. M. Silverberg, C. E. Spiekermann; *Visiting Assistant Professor:* N. Chokani; *Adjunct Assistant Professors:* J. P. Coulter, C. C. Daniel III, J. A. Daggarhart, P. A. Gnoffo, J. H. Hebrank, A. L. Patra, W. J. Yanta

INTERINSTITUTIONAL ADJUNCT GRADUATE FACULTY

S. Chandra, P. H. DeHoff

The Department of Mechanical and Aerospace Engineering offers graduate study leading to the Master of Mechanical Engineering, Master of Science and Doctor of Philosophy degrees. Entrance to the degree programs is based upon superior performance in a pertinent, accredited baccalaureate degree program.

Graduate study and research are available in the following areas:

(1) thermal sciences including classical and statistical thermodynamics, energy conservation and conversion, solar energy, alternative energy sources, heat and mass transfer; energy systems;

(2) sound and vibration technology including acoustic radiation, industrial and community noise control, transportation noise and hearing conservation, acoustic signal processing and computer vibration analysis;

(3) gas dynamics including subsonic, transonic, supersonic and hypersonic aerodynamics, lasers, plasmagasdynamics and combustion;

(4) computational fluid dynamics for inviscid flows, boundary layers and parabolized and complete Navier-Stokes equations for external and internal flows, grid generation;

(5) aerospace sciences including aeroelasticity, stability and control and aerospace propulsion; aerospace structures;

(6) mechanical sciences including machine vibrations, mechanical transients, materials processing, photoelasticity and experimental stress analysis, finite element analysis and transportation systems and vehicle safety; automatic control of active structures; design optimization;

(7) mechanical design, precision engineering and tribology;

(8) computer-aided design with dedicated graphics work stations, advanced interactive software and a dedicated VAX 11/785 computer.

Extensive laboratory facilities include subsonic and supersonic wind tunnels; extensive sound and vibration laboratories including anechoic chambers, a large reverberation room, a machinery noise laboratory with field test and analysis instrumentation, a signal processing laboratory, a computer graphics and vibration analysis laboratory using a Nicolet 6602 structural analysis system and a Tektronix 4114 terminal for finite-element analysis, a materials processing laboratory; an experimental stress analysis and photoelasticity laboratory; an aeroelasticity laboratory; automotive performance and emission control facility; a solar energy house and laboratory; a heat transfer laboratory; a precision engineering laboratory; and an applied energy research laboratory.

Computational facilities include VAX 11/785 and IBM 3081 computers, micro and array processors, minicomputers, terminals to facilities at NASA Langley Research Center and a Cray-2 at MCNC.

The objective of the department is to provide graduate education both in rigorous experimental and theoretical research and practitioner-oriented engineering design.

SELECTED ADVANCED UNDERGRADUATE COURSES

MAE 403 Air Conditioning. *Preq.: MAE 302, 3(3-0) F.*

- MAE 404 Refrigeration.** *Preq.: MAE 302. 3(3-0) S.*
- MAE 405 Mechanical Engineering Laboratory III.** *Preq.: MAE 306. 1(0-3) F,S.*
- MAE 406 Energy Conservation in Industry.** *Preqs.: MAE 301 or 307; jr. or sr. status in engineering. 3(2-3) F.*
- MAE 407 Steam and Gas Turbines.** *Preqs.: MAE 302, MAE 308, or MAE 355. 3(3-0) S.*
- MAE 408 Internal Combustion Engine Fundamentals.** *Preq.: MAE 302. 3(3-0) F.*
- MAE 409 Particulate Control in Industrial Atmospheric Pollution.** *Preq.: MAE 301 or equivalent. 3(3-0) F.*
- MAE 410 Convective Heat Transfer and Fluid Flow.** *Preqs.: MAE 301, MAE 308. 3(3-0) F.*
- MAE 411 Machine Component Design.** *Preqs.: MAE 315, 316. 3(3-0) F.*
- MAE 412 Energy Systems.** *Preqs.: MAE 302, MAE 410. 3(3-0) S.*
- MAE 415 Mechanical Engineering Analysis.** *Preqs.: MAE 302, 315, 316, EE 331. 3(3-0) F.*
- MAE 416 Mechanical Engineering Design.** *Preqs.: MAE 302, 315, 316, EE 331. 4(3-2) S.*
- MAE 431 Thermodynamics of Compressible Fluid Flow.** *Preqs.: MAE 301, MA 301, MAE 308. 3(3-0) S.*
- MAE 435 Principles of Automatic Control.** *Preq.: MA 301. 3(3-0) F,S.*
- MAE 442 Automotive Engineering.** *Preq.: Sr. in Engineering. 3(3-0) S.*
- MAE 452 Aerodynamics of V/STOL Vehicles.** *Preq.: MAE 355. 3(3-0) F.*
- MAE 455 Boundary Layer Theory.** *Preq.: MAE 355. 3(3-0) F.*
- MAE 456 Computational Methods in Aerodynamics.** *Preq.: CSC 302 and MAE 455. 3(3-0) S. Alt. yrs.*
- MAE 462 Flight Vehicle Stability and Control.** *Preqs.: MAE 261, 435. 3(3-0) F.*
- MAE 465 Propulsion II.** *Preq.: MAE 365. 4(3-3) F.*
- MAE 466 Propulsion II Laboratory.** *Preqs.: MAE 365; MAE 357; Coreq.: MAE 465. 1(0-3) F.*
- MAE 472 Aerospace Vehicle Structures II.** *2Preq.: MAE 371. 4(3-3) S.*
- MAE 473 Aerospace Vehicle Structure II Laboratory.** *Preq.: MAE 371; Coreq.: MAE 472. 1(0-3) S.*
- MAE 478 Aerospace Vehicle Design I.** *Preqs.: MAE 356, 472; Coreqs.: MAE 462, 465. 2(2-0). F.*
- MAE 479 Aerospace Vehicle Design II.** *Preq.: MAE 478. 3(1-6) S.*
- MAE 495 Special Topics in Mechanical and Aerospace Engineering.** *1-3 F,S.*

FOR GRADUATES AND ADVANCED UNDERGRADUATES

MAE 501 Advanced Engineering Thermodynamics. *Preqs.: MAE 302; MA 401 or MA 511. 3(3-0) F.* Thermodynamics of a general reactive system; conservation of energy and the principles of increase of entropy; the fundamental relation of thermodynamics; Legendre transformations; phase transitions and critical phenomena; equilibrium and stability criteria in different representation; irreversible thermodynamics. Introduction to statistical thermodynamics.

MAE 503 Advanced Power Plants. *Preq.: MAE 412. 3(3-0) F.* A critical analysis of the energy balance of thermal power plants, thermodynamics and economic evaluation of alternate schemes of development; study of recent development in the production of power.

MAE 504 Fluid Dynamics of Combustion I. *Preqs.: MAE 301, MAE 355 or MAE 308. 3(3-0) F.* Gas-phase thermochemistry including chemical equilibrium and introductory chemical kinetics. Homogeneous reaction phenomena. Subsonic and supersonic combustion waves in premixed reactants (deflagration and detonation). Effects of turbulence. Introduction to diffusion flame theory.

MAE 505 Heat Transfer Theory and Applications. *Preq.: MAE 410 or equivalent. 3(3-0) F.* Development of basic equations for steady and transient heat and mass transfer processes. Emphasis placed on the application of the basic equations to engineering problems in the areas of conduction, convection, mass transfer and thermal radiation.

MAE 506 Advanced Automotive Energy Systems. *Preq.: MAE 408. 3(3-0) S.* A critical study of the various cycles and energy systems for automotive transportation carried out. The feasibility of automotive Rankine cycle power plants, Sterling engines, gas turbines and hydrogen-air fueled engines discussed. Means of improving the efficiency and exhaust emissions of internal combustion engines and the use of alternative fuel sources considered.

MAE 510 Effects of Noise and Vibration on Man. *Preq.: MA 301. 3(3-0) F.* Study of effects of noise and vibration and design criteria available to establish acceptability of environments. Study of auditory and non-auditory response to noise and models available for predicting responses. Guidelines presented for designing equipment and environments to meet existing ANSI, ISO, ASTM and HVAC standards. Practical experience in using noise-vibration equipment.

MAE 513 Principles of Structural Vibration. *Preq.: MAE 315. 3(3-0) F.* Principles of structural vibration beginning from single and multi-degree of freedom systems and extending to distributed systems. Forced system response, vibration of strings, bars, shafts and beams and an introduction to approximate methods.

MAE 514 Noise and Vibration Control. *Preq.: MAE 315. 3(3-0) S.* Discussion of noise and vibration design criteria. Presentation of noise and vibration survey procedures. Discussion of the noise and vibration control model. Review of most common equipment noise sources and ways to achieve adequate control. Room acoustics, acoustics of walls, enclosures, vibration isolation and use of scale models are examples of topics covered during the course.

MAE 517 Instrumentation in Sound and Vibration Engineering. *Preq.: ECE 331; Coreq.: MAE 513. 3(3-0) S.* This course devoted to a presentation of measurement techniques and the theory and operation of transducers and amplifiers. An introduction to signal analysis techniques such as power spectral density and correlation also provided.

MAE 518 Acoustic Radiation I. *Preqs.: MA 301 and MAE 308 or MAE 356. 3(3-0) F.* An introduction to the principles of acoustic radiation from vibrating bodies and their related fields. The radiation of simple sources, the propagation of sound waves in confined spaces and transmission through different media considered.

MAE 519 Theory of Noise in Transportation Systems. *Preq.: MAE 550. 3(3-0) S.* A study of the basic noise generating mechanisms encountered in transportation systems. Coverage includes jet noise, propeller noise, helicopter noise, fan and compressor noise, aircraft induced community noise, surface vehicle noise models and efforts to control noise in transportation systems.

MAE (IE) 520 Industrial Robotics. *3(3-0) F.* (See industrial engineering.)

MAE 524 Principles of Structural Control. *Preq.: MAE 315; Coreq.: MAE 513. 3(3-0) F.* Principles of structural control beginning with single and two-degree of freedom systems and extending to distributed systems. State feedback, disturbance rejection, mode coupling, state estimation, pole placement. Applications to civil structures, path following in robotic structures, suspensions in automotive structures, flight control systems in aircraft structures and attitude control in space structures.

MAE 525 Advanced Flight Vehicle Stability and Control. *Preq.: MAE 462. 3(3-0) F.* Preliminary analysis and design of flight control systems to include autopilots and stability augmentation systems. Study of effects of inertial cross-coupling and nonrigid bodies on vehicle dynamics.

MAE 526 Inertial Navigation Analysis and Design. *Preq.: MAE 435 or 462. 3(3-0) S.* Performance analysis and engineering design of inertial navigation components, subsystems and systems. Development of transfer functions and application of linear system techniques to determine stability, transient response and errors of gyroscopes, accelerometers, stable platforms and inertial alignment systems. Error analysis and its significance. Preliminary analysis and design of typical inertial navigation systems for aircraft and marine vehicles.

MAE (MAT) 531 Materials Processing by Deformation. *Preq.: Six hrs. of solid mechanics and/or materials. 3(3-0) F.* The course involves a presentation of the mechanical and metallurgical fundamentals of materials processing by deformation. Topics to be discussed include: principles of metal working, friction, forging, rolling, extrusion, drawing, high energy rate forming, chipless forming techniques, manufacturing system concept in production.

MAE (MAT) 532 Fundamentals of Metal Machining Theory. *Preq.: Six hrs. of solid mechanics and/or materials. 3(3-0) S.* The course involves a presentation of the mechanical and metallurgical fundamentals of metal machining. Topics to be discussed include: mechanics of machining, temperatures generated, tool life and tool wear, lubrication, grinding process, electrical machining processes, surface integrity, economics, nomenclature of cutting tools.

MAE 533 Finite Element Analysis I. *Preq.: MAE 316 or MAE 472. 3(3-0) F.* Fundamental concepts of the finite element method for linear stress and deformation analysis of mechanical components. Development of truss, beam, frame, plane stress, plane strain, axisymmetric and solid elements. Isoparametric formulations. Introduction to structural dynamics. Practical modeling techniques and use of general-purpose codes for solving practical stress analysis problems.

MAE 535 Experimental Stress Analysis. *Preq.: MAE 316 or 371. 3(2-3) F.* Theoretical and experimental techniques of strain and stress analysis with emphasis on electrical strain gages and instrumentation, brittle coatings, grid methods and an introduction to photoelasticity. Laboratory includes an investigation and complete report of a problem chosen by the student under the guidance of the instructor.

MAE 536 Photoelasticity. *Preq.: MAE 316 or 371. 3(2-3) S. Alt. yrs.* Theory and experimental techniques of two- and three-dimensional photoelasticity including photoelastic coatings, photoplasticity and an application of photoelastic methods to the determination of stress-strain distributions in loaded members. Laboratory includes an investigation and complete report of a problem chosen by the student under the guidance of the instructor.

MAE 537 Mechanics of Composite Structures. *Preq.: MAE 316 or MAE 472. 3(3-0) F.* Manufacturing techniques with an emphasis placed on the selection of those which produce the most favorable end result. Classical plate theory, materials properties and failure theories. Micromechanics, repair, plate solutions and elasticity solutions covered as required to meet special interests of students.

MAE 538 Engineering Optics. *Preq.: Grad. standing. 3(3-0) S.* Fundamentals of geometric and physical optics as related to problems in engineering design and research. Characteristics of imaging systems including multi-element design, geometric and chromatic aberrations and effects of apertures. Properties of light sources and optical properties of material also covered. Diffraction, interference and scattering phenomena as related to optical measurements techniques. Introduction to lasers and holography.

MAE 540 Advanced Air Conditioning Design. *Preqs.: MAE 403, 404. 3(3-0) S.* Psychrometric process representations. Heating and cooling coil design. Heat pump design. Air washer design. Direct contact heat and mass transfer systems. Ventilation requirements, air dilution calculations. Cooling load calculations; CLTD, CLF and transfer functions methods. Room air distribution.

MAE 541 Advanced Machine Design I. *Preq.: MAE 416. 3(3-0) F.* An advanced treatment of stress analysis and mechanics of materials devoted to analytical methods of predicting the life of mechanical components. Development of the governing differential equations of elasticity. Analyses of beams, stress concentrations, pressurized pipes, rotating disks and contact stresses. The energy approach to elasticity problems also used as well as a brief introduction to plastic failure criteria.

MAE 542 Mechanical Design for Automated Assembly. *Preq.: Grad. standing or PBS status in engineering. 3(3-0) F.* Mechanical design principles important in high volume production using modern automated assembly technology. Production and component design for ease of assembly as dictated by part handling, feeding, orientation, insertion and fastening requirements. Existing product evaluation and redesign for improved assemblage.

MAE 543 Fracture Mechanics. *Preq.: MAE 316. 3(3-0) S.* Concept of the elastic stress intensity factor, Griffith energy balance, determination of the elastic field at a sharp crack tip via eigenfunction expansion methods, J integrals analysis, experimental determination of fracture toughness, fatigue crack growth, elastic-plastic crack tip fields. Emphasis given to modern numerical methods for determination of stress intensity factors, critical crack sizes and fatigue crack propagation rate predictions.

MAE 544 Real Time Robotics. *Preq.: Pascal, C, Fortran or Assembly language experience. 3(3-0) F.* Real-time programming for servo control using an embedded controller. Software and hardware interfacing for control of a D.C. servo device. Multi-tasking introduced to establish concurrent control of several processes, transforming the servo loop into a process that executes concurrently on a single board computer. Hands-on development systems and software emulators provided.

MAE 550 Foundations of Fluid Dynamics. *Preqs.: MAE 301, MAE 355 or MAE 308. 3(3-0) F.* Review of basic thermodynamics pertinent to gas dynamics. Detailed development of the general equations governing fluid motion in both differential and integral forms. Simplification of the equations to those for specialized flow regimes. Similarity parameters. Applications to simple problems in various flow regimes.

MAE 551 Airfoil Theory. *Preq.: MAE 355. 3(3-0) S.* Development of fundamental aerodynamic theory. Emphasis upon mathematical analysis and derivation of equations of motion, airfoil theory and comparison with experimental results. Introduction to supersonic flow theory.

MAE 552 Transonic Aerodynamics. *Preq.: MAE 356. 3(3-0) S.* A detailed study of the latest theoretical and experimental findings in transonic aerodynamics, including two-dimensional and axisymmetric flows.

MAE 553 Compressible Fluids. *Preq.: MAE 356 or MAE 431 or MAE 550. 3(3-0) F. Alt. yrs.* Equations of motion in supersonic flow. Prandtl-Meyer turns, method of characteristics, hodograph plane, supersonic wind tunnels, supersonic airfoil theory and boundary layer shock interaction.

MAE 554 Hypersonic Aerodynamics. *Preq.: MAE 356. 3(3-0) F.* A detailed study of the latest theoretical and experimental findings in hypersonic aerodynamics.

MAE 555 Aerodynamic Heating. *Preq.: MAE 356. 3(3-0) F.* A detailed study of the latest theoretical and experimental findings of the compressible laminar and turbulent boundary layers with special attention to the aerodynamic heating problem. Application of theory in the analysis and design of aerospace hardware.

MAE 556 Mechanics of Ideal Fluids. *Preq.: MAE 355 or MAE 308. 3(3-0) S.* Mass, momentum and energy conservation laws, flow kinematics and special forms of the governing equations (e.g., Euler equations and Bernoulli's equation). Solutions of Laplace's equation for the velocity potential. Applications of complex analysis for two-dimensional potential flows. Study of three-dimensional potential flows. Introduction to the effects of viscosity.

MAE 557 Dynamics of Internal Fluid Flow. *Preq.: MAE 356 or MAE 308. 3(3-0) F.* A general development of the governing equations of fluid motion with subsequent restriction to incompressible flow. Exact and approximate solutions of the Navier-Stokes equations for internal laminar flow and elementary boundary layer theory. Applications include: hydrodynamic lubrication, converging-diverging channel flows, entrance flows and turbulent internal flow.

MAE 558 Plasmagas dynamics I. *Preqs.: MAE 356, PY 414. 3(3-0) F.* Study of basic laws governing plasma motion for dense and rarefied plasmas, hydromagnetic shocks, plasma waves and instabilities, simple engineering applications.

MAE 559 Molecular Gas Dynamics I. *Preq.: MAE 550. 3(3-0) F.* Statistical mechanics as applied to the derivation of the equations of gas dynamics from the microscopic viewpoint. Collision processes, treatments of viscosity, heat conduction and electrical conductivity.

MAE 560 Computational Fluid Mechanics and Heat Transfer. *Preqs.: MA 501 or MA 512, MAE 550 or MAE 557. 3(3-0) S.* Introduction to the integration of the governing partial differential equations of fluid flow and heat transfer by numerical finite difference means. Methods developed for parabolic, hyperbolic and elliptical equations and applied to model equations. Error analysis and physical considerations emphasized.

MAE 561 Wing Theory. *Preq.: MAE 551. 3(3-0) S. Alt. yrs.* Inviscid flow fields over wings in subsonic flow discussed. Vortex lattice methods, lifting surface theories and panel methods developed for wings with attached flow and leading-edge separation. Aerodynamic characteristics calculated and the effects of planform and airfoil shapes determined.

MAE (MEA) 563 Geophysical Fluid Mechanics. *3(3-0) F. Alt. yrs.* (See marine, earth and atmospheric sciences.)

MAE (ECE) 565 Gas Lasers. *Preqs.: MAE 356 or equivalent, PY 407. 3(3-0) F.* Study of the principles, design and potential application of ion, molecular, chemical and atomic gas lasers.

MAE 570 Theory of Particulate Collection in Air Pollution Control. *Preq.: MAE 409 or grad. standing. 3(3-0) S.* Particulate matter is classified and its properties are described.

The motion of particles as applied to particulate collection is carefully analyzed. The elements of aerodynamic capture of particles are developed and applications in filtration and liquid scrubbing are considered. Fundamentals of acoustical, electrostatic and thermal precipitation are introduced. Sampling techniques and instrumentation are also considered.

MAE 586 Project Work in Mechanical Engineering. 1-6 F,S. Individual or small group investigation of a problem stemming from a mutual student-faculty interest. Emphasis placed on providing a situation for exploiting student curiosity.

MAE 589 Special Topics in Mechanical Engineering. *Preq.: Advanced undergrad. or grad. standing. 3(3-0) F,S.* Faculty and student discussions of special topics in mechanical engineering.

FOR GRADUATES ONLY

MAE 601 Statistical Thermodynamics. *Preq.: MAE 501. 3(3-0) S.* The conclusions of classical thermodynamics are analyzed and established from the microscopic viewpoint. Topics include: ensemble methods, partition functions, translational, rotational and vibrational energy modes of an ideal gas, chemical equilibrium, imperfect gases, dense fluids, critical-point theories, mean free path concepts, Boltzmann equation, hydrodynamic equations from kinetic theory and properties of disordered composite media.

MAE 603 Advanced Direct Energy Conversion. *Preq.: MAE 501. 3(3-0) F.* An engineering study of the modern developments in the field of conversion of heat to power in order to meet new technology demands. Thermoelectric, thermomagnetic, thermionic, photovoltaic and magneto-hydrodynamic effects and their utilization for energy conversion purposes, static and dynamic response, limitations imposed by the first and second laws of thermodynamics. Energy and entropy balances, irreversible sources, inherent losses, cascading, design procedures, experimental studies to determine the response and efficiency of various systems.

MAE 604 Fluid Dynamics of Combustion II. *Preq.: MAE 504. 3(3-0) S.* Advanced theory of detonation and deflagration. Ignition criteria. Direct initiation of detonation including blast-wave theory. Transition from deflagration to detonation. Combustion wave structure and stability. Liquid droplet and solid particle combustion.

MAE 608 Advanced Conductive Heat Transfer. *Preq.: MAE 505 or MA 501. 3(3-0) S.* A comprehensive, unified treatment of methodologies for solving multidimensional transient and steady heat conduction. Approximate and exact methods of solving nonlinear problems, including phase change, temperature-dependent thermal properties, nonlinear boundary conditions. Heat conduction in composite media and anisotropic solids. The use of finite integral transform and Green's function techniques.

MAE 609 Advanced Convective Heat Transfer. *Preq.: MAE 557. 3(3-0) S.* Advanced topics in steady and transient, natural and forced convective heat transfer for laminar and turbulent flow through conduits and over surfaces. Mass transfer in laminar and turbulent flow also covered. Topics on compressible flow with heat and mass transfer included.

MAE 610 Advanced Radiative Heat Transfer. *Preq.: MAE 505. 3(3-0) F.* A comprehensive and unified treatment of basic theories; exact and approximate methods of solution of radiative heat transfer and the interaction of radiation with conductive and convective modes of heat transfer in participating and non-participating media.

MAE 613 Analytical Methods in Structural Vibration. *Preq.: MAE 513. 3(3-0) S.* Classical problems in structural vibration for which analytical solutions are available. Shock response, energy formulations and applications to continuous and discretized systems including curved beams, membranes, plates, shells, cylinders, spheres and cones.

MAE 614 Computational Methods in Structural Vibration. *Preq.: CE 527 or MAE 513. 3(3-0) S.* Computational methods developed to analyze the field problems in structural vibration for which closed-form solutions are generally unavailable. Aimed primarily at linear systems, topics include: linearization and stability, computational methods for the eigensolutions and discretization by local function, global function and hybrid approaches, applications to undamped, damped and spinning assemblages of beams, rods, strings, shafts, membranes and plates.

MAE 615 Nonlinear Vibrations. *Preq.: MAE 513. 3(3-0) S. Alt. yrs.* A study of free and forced vibrations of non-linear systems with non-linear restoring forces and self-sustained oscillations. Various analytical and phase plane methods are developed and used in obtaining actual solutions. Emphasis placed on understanding properties unique to non-linear systems.

MAE 618 Acoustic Radiation II. *Preq.: MAE 518. 3(3-0) S.* Advanced treatment of the theory of sound generation and transmission. Topics include: techniques for solution of the wave equation, radiation from spheres, cylinders and plates, sound propagation in ducts, scattering.

MAE 619 Random Vibration. *Preq.: MAE 513. 3(3-0) F. Alt. yrs.* Mathematical description of stochastic processes. The stationary and ergodic assumptions and response analysis of mechanical systems to random excitation. Simulation of and failure due to random environments.

MAE 623 Mechanics of Machinery. *Preqs.: MAE 315, MA 512. 3(3-0) S. Alt. yrs.* Advanced applications of dynamics to the design and response analysis of dynamic behavior of machines and mechanical devices. Emphasis on developing competence in transforming real problems in dynamics into appropriate mathematical models whose analysis permits performance predictions of engineering value.

MAE 634 Finite Element Analysis II. *Preq.: MAE 533. 3(3-0) S.* Advanced treatment of finite element analysis for non-linear mechanics problems, including the most recent developments in efficient solution procedures. Plate bending and shell elements, computational plasticity and viscoplastic materials, large deformation formulations, initial stability and buckling, structural vibrations, incompressible elasticity, contact problems, flow in incompressible media, weighted residuals and field problems. Development of efficient algorithms for practical application.

MAE 640 Advanced Machine Design II. *Preq.: MAE 541. 3(3-0) S.* Continuation of MAE 541. Problems related to torsion, curved and non-symmetric beams, rings, plates and shells, and a brief introduction to fracture mechanics.

MAE 642 Mechanical Design Analysis. *Preq.: Nine hours of graduate credit in MAE. 3(3-0) F.* Lecture and project activity devoted to development of the ability to apply knowledge and experience in performing comprehensive design analysis of complete mechanical systems. Areas of interest to include critical problem recognition, system modeling, performance determination and optimization and reliability evaluation.

MAE 643 Mechanical Design Synthesis. *Preq.: MAE 642. 3(2-2) S.* Application of the basic philosophy and methodology of the complete design process to advanced mechanical system design. Individual and group experience in the conception, synthesis, analysis, optimization and implementation phases of feasibility, preliminary and final design studies; provided by means of comprehensive system design projects.

MAE 654 Dynamics of Real Fluids I. *Preq.: MAE 550 or 557. 3(3-0) S.* Exact solutions to the Navier-Stokes equations. Approximate solutions for low Reynolds numbers. Approximate solutions for high Reynolds numbers—incompressible boundary layer theory. Laminar and turbulent boundary layers in theory and experiment. Flow separation.

MAE 655 Dynamics of Real Fluids II. *Preq.: MAE 654. 3(3-0) F.* A continuation of MAE 654. Compressible laminar and turbulent boundary layers. Laminar and turbulent jets. The stability of laminar boundary layers with respect to small disturbances, transition from laminar to turbulent flow.

MAE 656 Turbulence. *Preq.: MAE 550. 3(3-0) S.* A development of the basic concepts and governing equations for turbulence and turbulent field motion. Formulations of the various correlation tensors and energy spectra for isotropic and nonisotropic turbulence. An introduction to turbulent transport processes, "free" turbulence, and "wall" turbulence.

MAE 658 Plasmagasdynamics II. *Preq.: MAE 558. 3(-0) S.* Quantum statistics and ionization phenomena. Charged particle interactions. Transport properties in the presence of electric and magnetic fields and nonequilibrium ionization.

MAE 659 Molecular Gas Dynamics II. *Preqs.: MAE 559, 601. 3(3-0) S.* A continuation of MAE 559. Approximate methods of solution to the Boltzmann equation. Modeling of the Boltzmann equation. Results obtained by the various methods of analysis.

MAE 660 Computational Fluid Dynamics. *Preq.: MAE 560. 3(3-0) F.* Advanced computational methods for integrating by use of finite differences the non-linear governing equations of fluid flow; the Euler equations, the boundary layer equations and the Navier-Stokes equations. Topics from the current literature covered.

MAE 661 Introduction to Rocket Propulsion. *Preq.: MAE 501. 3(3-0) F.* Review of the exterior ballistics and performance of rocket-propelled vehicles. Thermodynamics of real gases at high temperatures. Nonequilibrium flow in rocket nozzles.

MAE (MEA) 663 Advanced Geophysical Fluid Mechanics. *3(3-0) S. Alt. yrs.* (See marine, earth and atmospheric sciences.)

MAE (MEA) 664, 665 Perturbation Method in Fluid Mechanics I, II. *3(3-0) F,S.* (See marine, earth and atmospheric sciences.)

MAE 686 Advanced Topics in Mechanical Engineering. *Preq.: Grad. standing. 1-3 F,S.* Faculty and graduate student discussions of advanced topics in contemporary mechanical engineering.

MAE 695 Mechanical Engineering Seminar. *1(1-0) F,S.* Faculty and graduate student discussions centered around current research problems and advanced engineering theories.

MAE 699 Mechanical Engineering Research. *Preqs.: Grad. standing in mechanical engineering, consent of adviser. Credits Arranged.* Individual research in the field of mechanical engineering.

Microbiology

GRADUATE FACULTY

Professor L. W. Parks, Head

Professor J. J. Perry, Graduate Administrator

Professors: W. J. Dobrogosz, G. H. Elkan; *Adjunct Professor:* R. E. Kanich; *Associate Professors:* G. H. Luginbuhl, J. M. Mackenzie Jr., T. Melton, K. Tatchell; *Associate Professor (USDA):* P. E. Bishop; *Adjunct Associate Professor:* K. T. Kleeman; *Assistant Professor:* E. S. Miller; *Adjunct Assistant Professor:* W. S. Dallas

ASSOCIATE MEMBERS OF THE DEPARTMENT

Professors: P. B. Hamilton, H. M. Hassan, T. R. Klaenhammer, W. E. Kloos, J. G. Lecce; *Associate Professors:* E. V. De Buysscher, P. M. Foegeding, F. J. Fuller; *Assistant Professor:* P. E. Orndorff

The Department of Microbiology offers programs leading to the Master of Science and Doctor of Philosophy degrees. These are research oriented programs that require a dissertation based on personal research. For students wishing a more general education without the thesis requirement, the Master of Life Sciences degree is offered with an emphasis in microbiology.

Applicants should have a bachelor's degree in one of the biological or physical sciences including at least one course in microbiology and courses in organic chemistry and calculus. Deficiencies may be made up while in graduate school but will not be counted as credit toward a graduate degree.

There are no specific departmental requirements regarding courses of study. There is a core of basic courses in microbiology that will be in the programs of most graduate students who have not had equivalent courses previously. As many as half of the courses in most programs will be basic courses in related areas such as biochemistry, chemistry, genetics or toxicology.

At least one semester of half-time teaching experience is required of all Ph.D. candidates. All graduate students are expected to attend and participate in the seminar program every semester they are in residence. As a general rule the M.S. program requires two full years (including summers) beyond the B.S. level and the Ph.D. program requires two or three full years beyond the M.S. level.

SELECTED ADVANCED UNDERGRADUATE COURSES

MB 401 General Microbiology. *Preqs.: BS 100; CH 223 or CH 220. 4(3-3) F,S.*

MB (FS) 405 Food Microbiology. *Preq.: MB 401. 3(2-3) F.*

MB 411 Medical Microbiology. *Preq.: MB 401. 4(3-3) S.*

MB 490 Special Topics in Microbiology. *Preqs.: Three courses in MB and CI. 1-3 F,S,Sum.*

MB 491 Seminar in Microbiology. *Preq.: Jr. standing. 1(1-0) F.*

FOR GRADUATES AND ADVANCED UNDERGRADUATES

MB 501A,B,C Advanced Microbiology I (A-Metabolism; B-Physiology; C-Immunology). *Preq.: MB 401. 1-3 F.* Basic concepts and principles of three major areas of microbiology presented as a series of five-week minicourses: MB 501A, metabolism; MB 501B, physiology; MB 501C, immunology. Graduate students majoring in microbiology must take all sections or have equivalent knowledge. Others may enroll for specific minicourses.

Hassan, Lecce, Parks

MB 502A,B,C Advanced Microbiology II (A-Systematics; B-Virology; C-Pathogenesis). *Preq.: MB 401. 1-3 S.* Basic concepts and principles of three major areas of microbiology presented as a series of five-week minicourses: MB 502A, systematics; MB 502B, virology; MB 502C, pathogenesis. Graduate students majoring in microbiology must take all sections or have equivalent knowledge. Others may enroll for specific minicourses.

Elkan, Luginbuhl, Graduate Staff

MB 514 Microbial Metabolic Regulation. *Preqs.: MB 401, BCH 451 or BCH 551. 3(3-0) F.* An integrative perspective on bacterial physiology and metabolism through an analysis of metabolic regulatory functions.

Hassan, Parks

MB (SSC) 532 Soil Microbiology. *4(3-3) S.* (See soil science.)

MB 551 Immunology. *Preq.: MB 501C or equivalent. 3(3-0) S.* Principles of the immune mechanism of man and animals; interactions between cells of the immune system and their genetic basis; the molecular basis of the generation of diversity and selective processes in the immune system.

Graduate Staff

MB (ZO) 555 Protozoology. *4(2-6) S.* (See zoology.)

MB (PHY, PO, VMS) 556 Immunogenetics. *3(2-2) F.* (See poultry science.)

MB (GN) 558 Prokaryotic Molecular Genetics. *Preqs.: BCH 451 or BCH 551, GN 411, MB 401. 3(3-0) S.* Structure and function in prokaryotic molecular genetics, with emphasis on mutations and mutagenic pathways, transcriptional and translational regulation, RNA processing, DNA replication and recombination and characterization of recombinant DNA molecules. Applications of genetic and recombinant DNA techniques to microbial processes, including strain construction and enhancement of gene expression.

Miller

MB (BAE, CE) 570 Sanitary Microbiology. *3(2-3) S.* (See civil engineering.)

MB 571 Molecular Virology of Animal Viruses. *Preqs.: BCH 551, MB 401. 3(3-0) F.* Animal virus replication. Selected examples from each virus group illustrate the principles underlying lytic, persistent and tumor-inducing viral infection.

Graduate Staff

MB (BO) 574 Phycology. *3(1-4) S.* (See botany.)

MB (BO, PP) 575 The Fungi. *3(3-0) F.* (See botany.)

MB (BO, PP) 576 The Fungi—Lab. *1(0-3) F.* (See botany.)

MB 590 Topical Problems. *Preqs.: Grad. standing, CI. Credits Arranged. F,S.*

Graduate Staff

FOR GRADUATES ONLY

MB (SSC) 632 Ecology and Functions of Soil Microorganisms. 3(3-0) S. (See soil science.)

MB (VMS) 653 Advanced Immunology. 3(3-0) F. *Alt. yrs.* (See veterinary medical sciences.)

MB (GN) 660 Experimental Microbial Genetics. *Preqs.: BCH 561, GN 411, MB 401. 4(2-6) S.* Laboratory-oriented presentation of current methodologies and concepts in molecular microbial genetics and their application to strain construction, plasmid and phage manipulations, mutagenesis, cloning and genetic engineering of microorganisms.
Melton

MB 671 Molecular Virology of Animal Viruses. *Preqs.: BCH 551, MB 502B. 3(3-0) F.* Animal virus replication. Selected examples from each virus group illustrate the principles underlying lytic, persistent and tumor-inducing viral infection.
Graduate Staff

MB 690 Microbiology Seminar. 1(1-0) F,S.
Graduate Staff

MB 692 Special Problems in Microbiology. *Credits Arranged. F,S,Sum.*
Graduate Staff

MB 699 Microbiology Research. *Credits Arranged. F,S,Sum.*
Graduate Staff

Nuclear Engineering**GRADUATE FACULTY**

Professor T. S. Elleman, Acting Head

Associate Professor J. G. Gilligan, Graduate Administrator

Professors: R. P. Gardner, K. L. Murty, C. E. Siewert, P. J. Turinsky, K. Verghese, B. W. Wehring; Professors Emeriti: R. L. Murray, R. F. Saxe, E. Stam, L. R. Zumwalt; Associate Professor: J. M. Doster; Visiting Associate Professor: O. H. Auciello; Assistant Professor: O. E. Hankins

The discipline of nuclear engineering is concerned with the development of nuclear processes for energy production and with the applications of radiation for the benefit of society. The Department of Nuclear Engineering offers graduate study via courses and research leading to the Master of Nuclear Engineering, Master of Science and Doctor of Philosophy degrees.

Representative topics of investigation include nuclear, analytic, computational and experimental research in the neutronics, materials and thermal-hydraulics of aspects of fission reactors; radiation detection and measurement of basic physics parameters; applications of radioisotopes and radiation in industry, medicine and science; and plasma, plasma-material surface interactions and design cycles aspects of fusion reactors.

The department's one-megawatt PULSTAR reactor, which became operational in 1973, is similar in design, type of fuel and performance to modern power reactors. It is used for teaching, research and service in behalf of the University.

Also available for student use in research are radiation detection laboratories, NAA laboratory, nuclear materials laboratory, plasma and plasma-surface interaction laboratory, prompt gamma facility, neutron radiography unit, NMR facility, noise analysis equipment, IBM Model 3081 computer, VAX/750 minicomputer, many microcomputers, access to super computers and several other well-equipped laboratories.

Bachelor's degree graduates in any of the fields of engineering or physical sciences may be qualified for successful advanced study in nuclear engineering. Prior experience or course work in nuclear physics, differential equations and basic reactor analysis is helpful but may be gained during the first semester of graduate study.

Teaching assistantships, research assistantships and fellowships are available for qualified applicants. Opportunities are also available for graduate traineeships with utility companies and reactor manufacturers, providing a valuable combination of financial support and learning in the classroom, the research laboratory and on the job.

Thirty semester hours are required for the Master of Nuclear Engineering and M.S. degrees. Students may also work directly toward a Ph.D. degree. Interdisciplinary programs with other departments in the College of Engineering and the College of Physical and Mathematical Sciences are available.

The advent of competitive nuclear power and the ever-increasing need for reliable clean energy has created a strong demand for nuclear engineers to participate in all phases of the nuclear power field—environmental studies, siting, design, construction, testing, operation, licensing and evaluation. Graduates of the department find positions in industry, government and educational institutions, working with reactors in the several categories—thermal, fast breeder and fusion.

SELECTED ADVANCED UNDERGRADUATE COURSES

NE 401 Reactor Analysis and Design. *Preq.: C or better in NE 301. 4(3-2) S.*

NE 402 Reactor Engineering. *Preqs.: NE 302, MA 401. 4(3-2) F.*

NE 403 Nuclear Engineering Design Projects. *Preqs.: NE 401, NE 402. 3(2-3) S.*

NE 404 Radiological, Reactor, and Environmental Safety. *Preq.: NE 302 or NE 419. 3(3-0) S.*

NE 405 Reactor Systems. *Coreq.: NE 402. 3(3-0) F.*

NE (MAT) 409 Nuclear Materials. *Preq.: MAT 201. 2(2-0) S.*

NE 412 Nuclear Fuel Cycles. *Preq.: NE 302. 3(3-0) S.*

NE 414 Nuclear Power Plant Instrumentation. *Preqs.: NE students—ECE 331, 332; ECE students—NE 419. 3(3-0) S.*

NE 419 Introduction to Nuclear Engineering. *Preq.: PY 202 or PY 208. 3(3-0) F.*

NE 491 Special Topics in Nuclear Engineering. *Preq.: CI. 1-4 F,S.*

FOR GRADUATES AND ADVANCED UNDERGRADUATES

NE 508 Radiation Safety. *Preq.: NE 401 or NE 520. 3(2-3) S.* Presents the basic concepts of health physics, biological effects of radiation and calculation of radiation exposure. Topics include: radiation units, regulatory agencies and allowable limits of radiation, sources of radiation, dose calculations—external and internal, radiation dosimetry, reactor radiation sources and dose reduction with particular emphasis on shielding. Mani

NE (PY) 511 Nuclear Physics for Engineers. *3(3-0) F.* (See physics.)

NE 520 Radiation and Reactor Fundamentals. *Preqs.: MA 401 and NE 401 or equivalent. 2(2-0) F.* An introduction to radiation physics and reactor physics. Topics include atomic and nuclear decay processes, nuclear reactions, neutron slowing down and diffusion, criticality for bare and reflected reactors and reactor kinetics. Graduate Staff

NE 521 Nuclear Laboratory Fundamentals. *Preqs.: MA 401 and NE 401 or equivalent. 2(1-3) F.* Introduction to nuclear instrumentation and experimental techniques used in nuclear engineering research. Topics include radiation detection and spectroscopy, neutron instrumentation, statistical analysis, use of microcomputers and nuclear reactor operations. Graduate Staff

NE 522 Reactor Dynamics and Control. *Preq.: NE 401 or NE 520. 3(3-0) F.* Introduces the students to methods of describing and analyzing dynamic behavior of systems. These methods applied to reactor systems and the effects of feedbacks studies. Methods of measuring the behavior of reactor systems are described and logic systems for control and safety developed. Graduate Staff

NE 523 Reactor Analysis. *Preq.: NE 401 or NE 520. 3(3-0) F.* Basic models of neutron motion and methods of calculating neutron flux distributions in nuclear reactors. Emphasis on multigroup diffusion theory. Criticality search, neutron slowing down models, resonance absorption, thermalization and heterogeneous cell calculations. Objective is to enable students to read literature and perform relevant analysis in reactor physics. Verghe

NE 524 Reactor Heat Transfer. *Preq.: NE 401 or NE 520. 3(3-0) S.* Considers heat generation and transfer in nuclear power reactors. Topics include reactor heat generation, steady-state and transient heat conduction in reactor fuel elements, boiling heat transfer and single and two-phase flow. Doster

NE (MAT) 525 Nuclear Materials. *Preqs.: NE 409 or MAT 201, CI. 3(3-0) F.* Introduces students to properties and selection of materials for nuclear steam systems and to radiation effects on materials. Implications of radiation damage to reactor materials and material problems in nuclear engineering discussed. Topics include an overview of nuclear steam systems, crystal structure and defects, dislocation theory, mechanical properties, radiation damage, hardening and embrittlement due to radiation exposure and problems concerned with fission and fusion materials. Murty

NE 526 Radioisotopes Measurement Applications. *Preq.: NE 401 or NE 520. 3(3-0) S.* Introduces the student to measurement applications using radioisotopes. All the major tracing and gauging principles discussed and several specific applications treated in detail. Objective to familiarize student with design and analysis of industrial measurement systems which use radioisotopes. Gardner, Verghe

NE 527 Nuclear Engineering Analysis. *Preq.: NE 401 or NE 520. 3(3-0) S.* Presents fundamental material on: (1) numerical methods for solving the partial differential equations pertinent to nuclear engineering problems, (2) Monte Carlo simulation of radiation transport and (3) data and error analysis techniques including estimation of linear and nonlinear model parameters from experimental data. Gardner

NE 528 Principles of Fusion Reactors. *Preq.: NE 401 or NE 520. 3(3-0) S.* Provides an introduction to plasma concepts and fusion reactor design. Topics included: basics of thermonuclear reactions, charged particle collisions and radiation, plasma confinement, plasmas as fluids, formation and heating of plasmas and reactor concepts and design.

Gilligan, Hankins

NE 550 Laboratory Projects in Nuclear Engineering. *Preq.: NE 521. 3(1-6) F.* Enhancement of laboratory skills that are pertinent to nuclear engineering research sought through projects that require the student to design the experiment, assemble equipment, carry out the measurements and analyze and interpret data. Students work in groups of two and perform to completion two laboratory projects.

Graduate Staff

NE (MAT) 562 Materials Problems in Nuclear Engineering. *3(3-0) F.* (See materials science and engineering.)

NE (MAT) 573 Computer Experiments in Materials and Nuclear Engineering. *3(3-0) S.* (See materials science and engineering.)

NE 580 Plasma Generation and Diagnostics Laboratory. *Preq.: NE 528 or PY 508 or PY 509. 3(2-3) F. Alt. yrs.* Provides an introduction to experimental plasma generation and plasma diagnostic techniques. Lecture topics include high vacuum techniques, perturbing and non-perturbing probe techniques, and laser and emission spectroscopy. Laboratories utilize various methods of measuring plasma parameters discussed in lectures.

Auciello, Hankins

NE 581 Fusion Energy Engineering. *Preq.: NE 528. 3(3-0) F. Alt. yrs.* Describes and analyzes the technologies of devices necessary to produce fusion energy including vacuum technology, plasma heating and fueling, magnetics, special energy conversion, neutronics, materials, environment and safety. Design integration and the ensuing technological constraints are stressed.

Auciello, Gilligan

NE 591, 592 Special Topics in Nuclear Engineering I, II. *Preq.: CI. 3(3-0) F, S.*

Graduate Staff

FOR GRADUATES ONLY

NE 601 Reactor Theory and Analysis. *Preqs.: NE 523, 527. 3(3-0) F.* Theoretical aspects of neutron diffusion and transport related to the design computation and performance analysis of nuclear reactors. Principal topics are a unified view of the neutron cycle including slowing, resonance capture and thermalization; reactor dynamics and control; fuel cycle studies; and neutron transport methods. Background provided for research in power and test reactor analysis.

Turinsky

NE (MA) 607 Exact and Approximate Solutions in Particle Transport Theory. *Preq.: MA 501 or MA 511. 3(3-0) S.* The method of elementary solutions used to solve exactly basic problems in neutron-transport theory and related topics. In addition, the F_N method developed and used to establish concise approximate solutions in the realm of particle transport theory.

Siewert

NE 610 Nuclear Reactor Design Calculations. *Preq.: NE 523. 3(3-0) S. Alt. yrs.* Application of the digital computer to problems in reactor core nuclear design. Available reactor core physics computer modules studied and exercised. Systems and programs used by industry for power reactor core design and core follow described. A review of relevant analytic and numerical methods facilitates computer program development by the students.

Turinsky

NE 611 Radiation Detection. *Preq.: NE 526. 3(2-2) F.* Covers the advanced aspects of radiation detection such as computer methods applied to gamma-ray spectroscopy, abso-

lute detector efficiencies by experimental and Monte Carlo techniques, the use and theory of solid state detectors, time-of-flight detection experiments and Mossbauer and other resonance phenomena.
Gardner, Verghese

NE 612 Thermal Hydraulic Design Calculations. *Preq.: NE 524. 3(3-0) F. Alt. yrs.* An advanced presentation of thermal-hydraulic analysis of nuclear power systems. Topics include development of single phase and two-phase fluid flow evaluations, subchannel analysis, models of nonnuclear components, interphase phenomena and numerical solution methods relevant to design and safety analysis codes.
Doster

NE 620 Nuclear Radiation Attenuation. *Preqs.: NE 527. 3(3-0) F.* The physical theory and mathematical analysis of the penetration of neutrons, gamma-rays and charged particles. Analytical techniques include point kernels, transport theory, Monte Carlo and numerical methods. Digital computers employed in the solution of practical problems.
Doster

NE 621 Radiation Effects on Materials. *Preq.: NE 525. 3(3-0) F.* Interactions of radiation with matter, with emphasis on the physical effects. Current theories and experimental techniques discussed. Annealing of defects, radiation induced changes in physical properties and effects in reactor materials discussed.
Murty

NE 631 Reactor Kinetics and Control. *Preq.: NE 522. 3(3-0) S.* A study of the control of nuclear reactor systems. Basic control theory developed including the use of Bode, Nyquist and S-plane diagrams and state-variable methods. Reactor and reactor systems analyzed by these methods and control methods and optimum-control methods developed. Models for reactors and reactor-associated units, such as heat exchangers, discussed. The effects of non-linearities presented.
Saxe

NE 641 Radioisotopes Applications. *Preq.: NE 526. 3(3-0) F.* Principles and techniques of radioisotope applications presented. Topics include radiotracer principles, radiotracer applications to engineering processes, radioisotope gauging principles and charged particle, gamma ray and neutron radioisotope gauges.
Gardner, Verghese

NE 680 Plasma Engineering I. *Preq.: NE 528 or equivalent. 3(3-0) S. Alt. yrs.* The study of fundamental behavior of plasmas as applied to controlled thermonuclear devices and other application. Emphasis on energy and particle transport in relevant plasmas. Single particle and collective effects detailed.
Gilligan

NE 681 Plasma Engineering II. *Preq.: NE 528 or equivalent. 3(3-0) S. Alt. yrs.* Continued study of fundamentals in areas of plasma equilibriums, wave interactions, plasma heating, fueling, radiation and atomic physics. Numerical modelling of plasmas stressed.
Gilligan

NE 691, 692 Advanced Topics in Nuclear Engineering I, II. *Preq.: CI. 3(3-0) F,S.* A study of recent development in nuclear engineering theory and practice. Graduate Staff

NE 695 Seminar in Nuclear Engineering. *1(1-0) F,S.* Discussion of selected topics in nuclear engineering.
Graduate Staff

NE 699 Research in Nuclear Engineering. *Preq.: Grad. standing. Credits Arranged.* Individual research in the field of nuclear engineering.
Graduate Staff

Nutrition

GRADUATE FACULTY

Professor J. D. Garlich, Coordinator

Professors: G. L. Catignani, A. J. Clawson, W. E. Donaldson, R. W. Harvey, C. H. Hill, W. L. Johnson, E. E. Jones, D. R. Lineback, A. H. Rakes, H. A. Ramsey, J. C. H. Shih, H. E. Swaisgood; *Professors Emeriti:* L. W. Aurand, E. R. Barrick, E. S. Cofer, R. D. Mochrie, F. H. Smith, S. B. Tove, G. H. Wise; *Associate Professors:* M. T. Coffey, W. J. Croom, W. H. Hagler, J. F. Ort, K. R. Pond, J. W. Spears

Graduate study leading to either a Master of Science or a Doctor of Philosophy degree in nutrition may be taken in the interdepartmental nutrition program. Participating departments include animal science, biochemistry, food science and poultry science. Students reside and conduct research in one of these departments under the direction of an appropriate advisor. Co-majors involving a participating department or related discipline are permitted. Minors may be biochemistry, biotechnology, microbiology, physiology, statistics or other approved graduate field.

Research in the nutrition program may be conducted with a variety of species and at levels ranging from the molecular to the whole animal. The research may be described as nutritional biochemistry or experimental animal nutrition. Research facilities in each department are extensive and the problems under investigation are many and varied. Additional information about the program may be obtained by writing to Dr. J. D. Garlich, Coordinator, Nutrition Program, P.O. Box 7608, North Carolina State University, Raleigh, North Carolina 27695-7608.

SELECTED ADVANCED UNDERGRADUATE COURSES

NTR (ANS, PO) 415 Comparative Nutrition. *Preq.: CH 220 or both 221 and 223. 3(3-0) F.*

NTR (ANS) 419 Human Nutrition in Health and Disease. *Preqs.: BCH 451, NTR (ANS, PO) 415 or FS 400. 3(3-0) S.*

Associated courses related to nutrition are:

FS 400 Foods and Nutrition. *Preq.: CH 220. 3(3-0) F.*

FS 402 Food Chemistry. *Preq.: CH 220 or CH 221. 3(2-3) F.*

FOR GRADUATES AND ADVANCED UNDERGRADUATES

NTR (ANS) 516A,B,C,D Animal Nutrition Research Methods. *Preq.: BCH 451 or NTR (ANS) 415 or NTR (ANS) 419 or FS 400. 3(1-6) S.* Theory and practice of modern research techniques in ruminant and monogastric animal nutrition: NTR (ANS) 516A, nutritive evaluation of feedstuffs; NTR (ANS) 516B, biological evaluation of feeds and diets; NTR (ANS) 516C, blood and tissue analysis; NTR (ANS) 561D, forage and pasture evaluation. Students can register for any combination.

Graduate Staff

NTR (FS) 530 Human Nutrition. *3(3-0) S. Alt. yrs.* (See food science.)

NTR (ANS) 540 Ruminant Physiology and Metabolism. *3(3-0) F. Even yrs.* (See animal science.)

NTR 590 Topical Problems in Nutrition. *Preq.: Grad. or sr. standing. 1-6 F,S.* Analysis of current problems in nutrition. Also entails the scientific appraisal and solution of a selected problem designed to provide training and experience in research.

Graduate Staff

FOR GRADUATES ONLY

NTR 601 Protein and Amino Acid Metabolism. *Preqs.: BCH 551, ZO 421, a 400-level nutrition course. 3(3-0) S.* Protein and amino acid metabolism, regulation, dietary requirements and techniques for their investigation in human and other animals studied.

Garlich

NTR (ANS, PO) 605 Mineral Metabolism. *Preqs.: ANS (NTR, PO) 415 or BCH 551, BCH 451 and ZO 421. 3(3-0) F.* Requirements, function, distribution, absorption, excretion and toxicity of minerals in humans and domestic animals. Interactions between minerals and other factors affecting mineral metabolism or availability. Emphasis on mechanisms associated with mineral functions and the metabolic bases for the development of signs of deficiency.

Spears

NTR (FS) 606 Vitamin Metabolism. *Preqs.: ANS (NTR, PO) 415 and BCH 551. 2(2-0) F. Even yrs.* Structures, chemical and physical properties, functions, deficiency symptoms, distribution, absorption, transport, metabolism, storage, excretion and toxicity of the vitamins in humans and domestic animals. Nutritional significance of the essential fatty acids and the metabolism of prostaglandins, prostacyclins and leucotrienes.

Catignani, Garlich, Jones, Shih

NTR 608 Energy Metabolism. *Preqs.: BCH 551 and an introductory NTR course. 3(3-0) F.* This course relates biochemical and physiological events within the cell, tissue, organ and system with the nutrient needs as sources of energy for productive animal life. Digestion, absorption and metabolism of energy sources discussed. Processes of energy transformations within living structures presented in relation to energetics, biological oxidations, coupled reactions, anabolic and catabolic systems, metabolic control, partitioning and efficiency.

Spears

NTR 690 Advanced Special Problems in Nutrition. *Preq.: Grad. standing. 1-6 F,S.* Directed research in a specialized phase of nutrition designed to provide experience in research methodology and philosophy.

Graduate Staff

NTR 699 Research in Nutrition. *Preq.: Grad. standing. Credits Arranged. F,S.* Original research preparatory to the thesis for the Master of Science or Doctor of Philosophy degree.

Graduate Staff

Occupational Education

For a listing of graduate faculty and departmental information, see occupational education under education.

Operations Research

GRADUATE FACULTY

Professor S. E. Elmaghraby, Chairman and Program Director

Professors: B. B. Bhattacharyya, J. W. Bishir, W. Chou, H. A. Devine, J. C. Dunn, S.-C. Fang, R. M. Felder, W. S. Galler, H. J. Gold, R. E. Hartwig, T. J. Hodgson, C. T. Kelley, C. J. Maday, D. F. McAllister, C. D. Meyer, A. A. Nilsson, H. L. W. Nuttle, H. J. Perros, E. L. Peterson, H. Sagan, W. J. Stewart; *Professor Emeritus:* N. J. Rose; *Associate Professors:* T. L. Honeycutt, T. W. Reiland, J. Rodrigues, C. D. Savage, C. E. Smith; *Assistant Professors:* N. M. Bengtson, Y. Fathi, R. Haas, R. E. King, M. F. M. Stallmann, S. J. Wright

Operations research is a graduate program of a interdisciplinary nature, governed by an administrative board and the program committee, and administered through the office of the program director.

The program offers the degrees of Master of Science and Doctor of Philosophy. Both are research degrees requiring a thesis. A foreign language is not required at the master's level and is optional with the student's advisory committee at the doctoral level. A brochure is available which describes in more detail the requirements for both degrees.

An advanced program of study in operations research implies intensive study in at least two of the following areas: mathematical optimization, dynamical systems and control theory, stochastic systems, econometrics and economic decision theory and information and cybernetics.

For students who wish to combine their study in OR with studies in another field, the program offers a joint program at the Ph.D. level in computer studies and another joint program at the M.S. level with management. Furthermore, the OR program encourages co-majoring with mathematics, statistics or any field of science and engineering. Please consult the OR brochure for more details.

CENTRAL COURSES

FOR GRADUATES AND ADVANCED UNDERGRADUATES

OR 501 Introduction to Operations Research. *Preqs.: MA 421 or ST 421 or ST 371 and ST 372. 3(3-0) F,S.* OR Approach: modeling, constraints, objective and criterion. The problem of Multiple criteria. Optimization, Model validation. The team approach. Systems Design. Examples. OR Methodology: mathematical programming; optimum seeking; simulation, gaming; heuristic programming. Examples. OR Applications; theory of inventory; economic ordering under deterministic and stochastic demand. The production smoothing problem; linear and quadratic cost functions. Waiting line problems: single and multiple servers with Poisson input and output. The theory of games for two-person competitive situations. Project management through PERT-CPM. Elmaghraby, Fathi

OR (IE, MA) 505 Linear Programming. *Preq.: MA 405. 3(3-0) F,S.* An introduction including: applications to economics and engineering; the simplex method and its main variants; parametric programming and post-optimality analysis; duality matrix games, linear systems solvability theory and linear systems duality theory; polyhedral sets and cones, including their convexity and separation properties and dual representations; equilibrium prices, Lagrange multipliers, subgradients and sensitivity analysis.

Fathi, Peterson

OR 506 Algorithmic Methods in Nonlinear Programming. *Preqs.: MA 301, MA 405, knowledge of computer language, such as FORTRAN or PL1. 3(3-0) S.* Introduction to methods for obtaining approximate solutions to unconstrained and constrained minimization problems of moderate size. Emphasis on geometrical interpretation and actual coordinate descent, steepest descent, Newton and quasi-Newton methods, conjugate gradient search, gradient projection and penalty function methods for constrained problems. Specialized problems and algorithms will be treated as time permits. Fang, Fathi

OR (IE) 509 Dynamic Programming. *Preqs.: MA 405, ST 421. 3(3-0) S.* An introduction to the theory and computational aspects of dynamic programming and its application to sequential decision problems. Elmaghraby

OR 520 Theory of Activity Networks. *Preqs.: OR 501, OR (IE, MA) 505. 3(3-0) S. Alt. yrs.* Introduction to graph theory and network theory. A discussion in depth of the theory underlying (1) deterministic activity networks (CPM): optimal time-cost trade offs; the problem of scarce resources; (2) probabilistic activity networks (PERT): critical evaluation of the underlying assumptions; (3) generalized activity networks (GERT, GAN): applications of signal flow graphs and semi-Markov process to probabilistic branching; relation to the theory of scheduling. Elmaghraby

OR (CHE) 527 Optimization of Engineering Processes. *Preqs.: CHE 451 or OR 501, FORTRAN programming. 3(3-0) F.* The formulation and solution of process optimization problems, with emphasis on nonlinear programming techniques. Computer implementation of optimization algorithms and structuring of process models to increase computational efficiency. Felder

OR (E, MA) 531 Dynamic Systems and Multivariable Control I. *Preqs.: MA 301, MA 405. 3(3-0) F.* Introduction to the modeling, analysis and control of linear discrete-time and continuous-time dynamical systems. State space representations and transfer methods. Controllability and observability. Realization. Applications to biological, chemical, economic, electrical, mechanical and sociological systems. Dunn, Rose

OR (IE) 561 Queues and Stochastic Service Systems. *Preq.: MA 421. 3(3-0) F.* General concepts of stochastic processes introduced. Poisson processes, Markov processes, and renewal theory presented. These then used in the analysis of queues, starting with a completely memoryless queue to one with general parameters. Applications to many engineering problems considered. Bengtson, Stewart

OR (CSC, ECE, IE) 562 Computer Simulation Techniques. *3(3-0) F.* (See computer science.)

OR (BMA, ST) 575 Decision Analytic Modeling. *4(3-2) F. Alt. yrs.* (See statistics.)

OR (CSC, MA) 585 Graph Theory. *Preq.: MA 231 or 405. 3(3-0) F.* Basic concepts of graph theory. Trees and forests. Vector spaces associated with a graph. Representation of graphs by binary matrices and list structures. Traversability. Connectivity. Matchings and assignment problems. Planar graphs. Colorability. Directed graphs. Applications of graph theory with emphasis on organizing problems in a form suitable for computer solution. Savage

OR (IE, MA) 586 Network Flows. *Preq.: OR (IE, MA) 505 or equivalent. 3(2-2) S. Alt. yrs.* This course studies problems of flows in networks. These problems include the determination of the shortest chain, maximal flow and minimal cost flow in networks. The relationship between network flows and linear programming developed as well as problems with nonlinear cost functions, multi-commodity flows and the problem of network synthesis. Nuttle, Stallmann

OR 591 Special Topics in Operations Research. *Preq.: CI. 1-3 F,S,Sum.* Individual or small group studies of special areas of OR which fit into the students' programs of study and

which may not be covered by other OR courses. Furthermore, the course serves as a vehicle for introducing new or specialized topics at the introductory graduate level.

Graduate Staff

FOR GRADUATES ONLY

OR (CSC) 605 Large Scale Linear Programming Systems. *Preqs.: OR 505 and FORTRAN programming experience. 3(3-0) Alt. S.* A study of the specialized algorithms for the efficient solution of large scale LP problems. Includes: parametric programming, bounded variable algorithms, generalized upper bounding, decomposition, separable programming and mixed integer programming. Emphasis is on gaining firsthand practical experience with current computer codes and computational procedures.

Fang, Haas

OR (MA, ST) 606 Nonlinear Programming. *Preq.: OR (IE, MA) 505. 3(3-0) S.* This course provides an advanced mathematical treatment of the analytical and algorithmic aspects of finite dimensional nonlinear programming. It includes an examination of the structure and effectiveness of computational methods for unconstrained and constrained minimization. Special attention will be directed toward current research and recent developments in the field.

Fang, Peterson

OR 609 Advanced Dynamic Programming. *Preqs.: OR 509, MA 541. 3(3-0) F. Alt. yrs.* Introduction to measure theoretic concepts, review of finite state Markov processes, theory of Markovian programming, discrete decision processes, continuous time dynamic programming, relation to calculus of variation and the Maximum Principle. Emphasis throughout is on recent theoretical development in the field. (Offered in alt. years.)

Elmaghraby

OR (BMA, MA, ST) 610 Stochastic Modeling. *3(3-0) S. Alt. yrs.* (See biomathematics.)

OR (BMA) 611 System Modeling Theory. *3(3-0).* (See biomathematics.)

OR (MA) 614 Integer Programming. *Preqs.: MA 405, OR (MA, IE) 505; Coreq.: Some familiarity with computers (e.g., CSC 111). 3(3-0) S. Alt. yrs.* Study of general integer programming problems and principal methods of solving them. Emphasis on intuitive presentation of ideas underlying various algorithms rather than detailed description of computer codes. The students have some "hands on" computing experience that should enable them to adapt the ideas presented in the course to integer programming problems they may encounter.

Fathi, Stallmann

OR (MA) 629 Vector Space Methods in System Optimization. *Preqs.: MA 405, 511 or equivalent. 3(3-0) F.* Introduction to algebraic and function-analytic concepts used in system modeling and optimization: vector space, linear mappings, spectral decomposition, adjoints, orthogonal projection, quality, fixed points and differentials. Emphasis on geometric insight. Topics include least square optimization of linear systems, minimum norm problems in Banach space, linearization in Hilbert space, iterative solution of system equations and optimization problems. Broad range of applications in operations research and system engineering including control theory, mathematical programming, econometrics, statistical estimation, circuit theory and numerical analysis.

Dunn, Sagan

OR (E, MA) 631 Dynamic Systems and Multivariable Control II. *Preq.: OR (E, MA) 531. 3(3-0) S. Alt. yrs.* Stability of equilibrium points for nonlinear systems. Liapunov functions. Unconstrained and constrained optimal control problems. Pontryagin's maximum principle and dynamic programming. Computation with gradient methods and Newton methods. Multidisciplinary applications.

Dunn, Rose

OR (CSC, IE) 662 Stochastic Simulation Design and Analysis. *3(3-0) S.* (See computer science.)

OR 691 Special Topics in Operations Research. *Preqs.: OR 501, OR (IE, MA) 505. 3(3-0) F, S, Sum.* The purpose of this course is to allow individual students or small groups of

students to take on studies of special areas in OR which fit into their particular program and which may not be covered by other OR courses. The work directed by a qualified faculty member and in some instances by visiting professors. The subject matter in any year dependent on the students and the faculty members.
Graduate Staff

OR (IE, MA) 692 Special Topics in Mathematical Programming. *Preqs.: OR (IE, MA) 505. 3(3-0) F,S,Sum.* The study of special advanced topics in the area of mathematical programming. New techniques and current research in this area discussed. The faculty responsible for this course select according to their preference and interest the areas to be covered during the semester. This course not necessarily taught by an individual faculty but can, on occasion, be a joint effort of several faculty members from this university as well as visiting faculty from other institutions. To date, courses on Theory of Networks, Optimal Control Algorithms and Integer Programming have been offered under the umbrella of this course. It is anticipated that these topics will be repeated in the future, together with other topics.
Graduate Staff

OR 695 Seminar in Operations Research. *Preq.: Enrollment in OR as a major or minor. 1(1-0) F,S.* Seminar discussion of operations research problems. Case analyses and reports. Graduate students with minors or majors in operations research are expected to attend throughout the period of their residence.
Elmaghraby

OR 699 Project in Operations Research. *Preq.: Variable. 1-3 F,S,Sum.* Individual research by graduate students minoring and majoring in operations research. Research may be done under the operations research faculty member meeting the interest need of the student.
Graduate Staff

SUGGESTED COGNATE COURSES

Cognate courses in the operations research program are courses often included in programs of study but which carry other departmental designations. They cover subject matter closely related to operations research and provide additional insight into the basis or application of operations research techniques. Students should not assume they will be able to include any of the cognate courses in their own program of study unless they have made previous arrangements with their faculty advisor.

Biomathematics

BMA (MA, ST) 571, 572 Biomathematics I & II

Chemical Engineering

CHE 525 Chemical Process Control

Civil Engineering

CE 575 Civil Engineering Systems

Computer Science

CSC 505 Design and Analysis of Algorithms

CSC (MA) 529, 530 Numerical Analysis I, II

CSC (ECE) 671 Advanced Computer Performance Modelling

Economics and Business

- EB 650 Economic Decision Theory
 EB (ST) 651 Econometrics
 EB (ST) 652 Topics in Econometrics

Electrical and Computer Engineering

- ECE 516 System Control Engineering
 ECE (CSC) 521 Digital Computer Technology and Design
 ECE 691 Special Studies in Electrical Engineering

Industrial Engineering

- IE 523 Production Planning, Scheduling and Inventory Control
 IE 547 Reliability Engineering
 IE 548 Quality Engineering
 IE 611 The Design of Production Systems
 IE 622 Inventory Control Methods II

Mathematics

- MA (ST) 541 Theory of Probability I
 MA (ST) 542 Introduction to Stochastic Processes
 MA (ST) 617, 618 Measure Theory and Advanced Probability
 MA 622 Linear Transformations and Matrix Theory
 MA 623 Theory of Matrices and Applications

Statistics

- ST 583 Introduction to Statistical Decision Theory
 ST 613 Time Series Analysis: Time Domain
 ST 614 Time Series Analysis: Frequency Domain

Pest Management**GRADUATE FACULTY**

Associate Professor Blanche C. Haning, *Program Coordinator*

Professors: J. T. Ambrose, C. S. Apperson, C. W. Averre III, R. C. Axtell, J. S. Bacheler, M. K. Beute, J. R. Bradley Jr., W. M. Brooks, G. A. Carlson, H. D. Coble, F. T. Corbin, J. M. Davis, E. J. Dunphy, H. J. Gold, F. P. Hain, G. G. Kennedy, W. M. Lewis, L. D. King, T. J. Monaco, G. C. Rock, D. P. Schmitt, T. J. Sheets, W. A. Skroch, R. E. Stinner, T. B. Sutton, J. W. Van Duyn, A. D. Worsham; *Professor (USDA):* R. A. Reinert; *Associate Professors:* J. J. Arends, J. E. Bailey, R. L. Brandenburg, R. I. Bruck, F. Gould, H. M. Linker, J. R. Meyer, M. M. Peet, G. J. San Julian, P. S. Southern; *Assistant Professor:* D. L. Hoag

The concept of integrated pest management (IPM) combines the theoretical and practical aspects of cultural, biological and chemical control into effective systems that maintain pest populations at levels that minimize economic and environmental damage. This approach and its implementation are opening new

career opportunities for broadly informed individuals who understand the basic biology and ecology of pests and the systems with which they are associated.

Graduate study in integrated pest management draws upon faculty from several departments, especially plant pathology, entomology, crop science and horticultural science. The Integrated Pest Management Teaching Subcommittee establishes the general requirements. Each student's advisory committee must include a member of the IPM graduate faculty. All programs must have the approval of the chairman of the IPM Teaching Subcommittee.

A graduate minor in pest management emphasizing agricultural crops is available for the Master of Science degree. This minor provides students with an understanding of the theory, purpose and practice of integrated pest management. Required courses or their equivalents are PM 415, Principles of Pest Management; PM 490, Pest Management Seminar or PM 595, Topical Problems in Integrated Pest Management, and at least one graduate level course each in plant pathology, entomology and weed science. A course in ecology also is recommended. This plan can also be accommodated in the Master of Agriculture degree program.

Additionally, a concentration in pest management is available within the Master of Agriculture degree and is identified by "Pest Management" on the transcript. This concentration involves a minimum of 36 credit hours and allows interdisciplinary programs of study tailored to students' needs. It includes graduate course work from at least four closely related disciplines and a minimum 3-month internship in the field. Opportunities for teaching and observing or cooperating in research are available. In the crop production and protection area the following courses or their equivalents are required: PP 515, Epidemiology and Plant Disease Control; ENT 562, Insect Pest Management in Agricultural Crops; SSC 541, Soil Fertility and three hours of advanced course work in weed science. Deficiencies in basic course work in the crop and pest disciplines including integrated pest management will be taken in addition to these minimum requirements. Graduate students enrolled in this program are located in the department of their major professor and participate in departmental activities, including seminar.

Additional information may be obtained by contacting a member of the Graduate Faculty or the IPM Program Coordinator, 2705 Bostian Hall, Box 7611, North Carolina State University, Raleigh, North Carolina 27695-7611.

SELECTED ADVANCED UNDERGRADUATE COURSES

PM 415 Principles of Pest Management. *Preqs.: ENT 312, PP 315, BO (ZO) 360; Coreq.: CS 414. 4(3-3) F.*

PM 490 Pest Management Seminar. *Preq.: PM 415. 2(1-1) S.*

FOR GRADUATES AND ADVANCED UNDERGRADUATES

PM 590 Advanced Topics in Integrated Pest Management. *Preq.: PM 405 or PM 415. 1-6 F,S,Sum.* Directed studies in Integrated Pest Management. Provides opportunity for advanced students to increase their understanding of current IPM philosophy, literature, research and technology through instruction or work experience in the field.

Graduate Staff

PM 595 Topical Problems in Integrated Pest Management. *Preq.: PM 415. 2(1-2) S.* One weekly lecture followed by discussions and projects relating to current topics in integrated pest management (IPM) under the guidance of interdisciplinary faculty teams; improves understanding of the depth and complexities of IPM and opportunities and limitations for its implementation. Haning

Students are advised to review course listings in such relevant departments as animal science, crop science, economics and business, entomology, horticultural science, plant pathology, soil science, the biomathematics program and the College of Forest Resources.

Physics

GRADUATE FACULTY

Professor R. R. Patty, Head

Professor G. E. Mitchell, Associate Head and Graduate Administrator

Professors: K. T. Chung, S. R. Cotanch, W. R. Davis, W. O. Doggett, R. E. Fornes, C. R. Gould, D. G. Haase, G. L. Hall, A. W. Jenkins Jr., C. E. Johnson, G. H. Katzin, F. Lado Jr., G. Lucovsky, J. D. Memory, J. Y. Park, J. S. Risley, D. E. Sayers, J. F. Schetzina, L. W. Seagondollar, D. R. Tilley; *Professors Emeriti:* J. T. Lynn, E. R. Manring, A. C. Menius Jr.; *Associate Professors:* J. Bernholz, G. C. Cobb Jr., J. W. Cook Jr., K. L. Johnston, M. A. Klenin, J. R. Mowat, R. J. Nemanich, M. A. Paesler, G. W. Parker III; *Assistant Professors:* D. C. Ellison, S. P. Reynolds

ASSOCIATE MEMBERS OF THE DEPARTMENT

Professors: J. M. A. Danby, J. Narayan, D. L. Ridgeway; *Associate Professors:* R. N. Kolbas, L. K. Norris

Study in physics is available leading to the degrees of Master of Science and Doctor of Philosophy. Computing facilities include a departmental VAX 11/750 computer plus access to a Cray Y-MP located at the North Carolina Supercomputing Center in Research Triangle Park. The Triangle Universities Nuclear Laboratory, located on the Duke University campus, is jointly staffed by Duke University, the University of North Carolina at Chapel Hill and North Carolina State University. The major facilities are a 15 MeV model FN tandem Van de Graaff Accelerator with various polarized beams and targets and on-line computer facilities.

Experimental and theoretical research is being performed in atomic and molecular physics, nuclear physics, plasma physics and condensed matter physics. Theoretical work is in progress in relativity and general field theory, statistical theory and astrophysics.

Programs of study leading to the Master of Science degree require a minimum of 30 semester hours; a thesis is required.

The Doctor of Philosophy degree is granted on successful completion of examinations, independent research and the submission of an acceptable dissertation. A minor area of study is required.

A large number of teaching and research assistantships is available. An out-of-state student holding such an assistantship may be eligible for reduced tuition charges.

SELECTED ADVANCED UNDERGRADUATE COURSES

PY 401, 402 Quantum Physics I, II. *Preq.: PY 411. 3(3-0) F,S.*

PY 407 Introduction to Modern Physics. *Preqs.: PY 208, MA 202. 3(3-0) F,S.*

PY 410 Introductory Nuclear Physics. *Preq.: PY 202 or 208. 4(3-2) S.*

PY 411, 412 Mechanics I, II. *Preqs.: PY 203 or 208, MA 301. 3(3-0) F,S.*

PY 413 Thermal Physics. *Preq.: PY 202 or 208; Coreq.: MA 301. 3(3-0) S.*

PY 414, 415 Electromagnetism I, II. *Preqs.: PY 203 or 208 and MA 301. 3(3-0) F,S.*

PY 441 Spacetime Physics. *Preq.: PY 203 or 407. 3(3-0) S.*

PY 451 Electronics for Physicists. *Preq.: PY 414; Coreq.: PY 415. 3(1-4) F.*

PY 452 Advanced Physics Laboratory. *Preqs.: Sr. standing and CI. 1(0-3) F,S.*

PY 499 Special Problems in Physics. *Preq.: Consent of department. 1-6 F,S.*

FOR GRADUATES AND ADVANCED UNDERGRADUATES

PY 506 Nuclear and Subatomic Physics. *Preqs.: PY 203 or 407; PY 412. 3(3-0) F.* An introduction to nuclear and subatomic phenomena: properties of nuclear radiations and detectors, accelerators, nuclear forces and nuclear structure, elementary particles, fundamental symmetries and conservation laws. Gould

PY 508 Ion and Electron Physics. *Preq.: PY 414. 3(3-0) F.* Topics covered: charged particle dynamics, introduction to plasma physics, processes in ionized gases, electron emission and the physics of electron beams. Doggett

PY 509 Plasma Physics. *Preq.: PY 414. 3(3-0) F.* The individual and collective motion of charged particles in electric and magnetic fields and through ionized gases. Doggett

PY 510 Nuclear Physics II. *Preq.: PY 410. 4(3-2) S.* The properties of the atomic nucleus as revealed by radioactivity, nuclear reactions and scattering experiments with emphasis on the experimental approach. The laboratory stresses independent research and offers project work in nuclear spectroscopy and in neutron physics. Graduate Staff

PY (NE) 511 Nuclear Physics for Engineers. *Preq.: PY 410. 3(3-0) F.* The properties of atomic nuclei, of nuclear radiations and of the interaction of nuclear radiation with matter. Emphasis on the principles of modern equipment and techniques of nuclear measurement and their application to practical problems. Graduate Staff

PY 516 Physical Optics. *Preq.: PY 415. 3(3-0) F.* Physical optics with the major emphasis on the wave properties of light. Boundary conditions, interference and diffraction, optics of thin films, fiber optics and applications to absorption, scattering and laser operation. A background in Maxwell's equations and vector analysis required. Johnson

PY 517 Atomic and Molecular Physics. *Preqs.: PY 401, 412. 3(3-0) S.* The quantum mechanical treatment of structure and spectra for atoms and molecules. Topics include the hydrogen atom, helium atom, multielectron atoms, selection rules, diatomic and simple polyatomic molecules and nuclear magnetic resonance spectroscopy. Mowat

PY 521 Statistical Physics I. *Preqs.: PY 401, PY 413. 3(3-0) S.* The basic elements of kinetic theory and equilibrium statistical mechanics, both classical and quantum; applications of the techniques developed to various ideal models of noninteracting particles.

Jenkins

PY 531 Advanced Placement Physics for Secondary School Teachers. *Preq.: Teaching certificate. 6(6-0) Sum.* A preparation for teaching advanced placement physics to high school students. A review of the physics content on the AP curriculum and discussion of teaching techniques, demonstrations and laboratories for use in such a program.

Graduate Staff

PY 543 Astrophysics. *Preqs.: PY 203 or 407; PY 411. 3(3-0) S.* The basic physics necessary to investigate, from observational data, the internal conditions and evolution of stars. Topics include the formation and structure of spectral lines, methods of energy generation and transport, stellar structure, degeneracy, white dwarfs and neutron stars.

Reynolds

PY (ECE) 552 Introduction to the Structure of Solids. *Preq.: PY 401. 3(3-0) S.* Basic considerations of crystalline solids, metals, conductors and semiconductors.

Bernhole

PY 553 Introduction to the Structure of Solids II. *Preq.: PY 552 or equivalent. 3(3-0) F.* A study of the properties of semiconductors, superconductors, magnets, ferroelectrics and crystalline defects and dislocations.

Paesler

PY (MA) 555 Mathematical Introduction to Celestial Mechanics. *3(3-0) F.* (See mathematics.)

PY (MA) 556 Orbital Mechanics. *3(3-0) S.* (See mathematics.)

PY 561 Electronics for Physicists. *Preq.: Grad. standing. 3(1-4) S.* Analog and digital electronics laboratory course serving as an introduction to the use of modern instrumentation required for experimental research in physics. Bipolar and field effect transistors, operational amplifiers, oscillators, power supplies, analog-digital and digital-analog conversion and digital logic circuits.

Cobb

PY 581, 582 Quantum Mechanics I, II. *Preqs.: MA 512; PY 411 or 414; grad. standing or permission of the grad. administrator. 3(3-0) F,S.* Fundamental concepts and formulations, including interpretation and techniques, and the application of theory to simple physical systems, such as the free particle, the harmonic oscillator, the particle in a potential well and central force problems. Other topics include approximation methods, identical particles and spin, transformation theory, symmetries and invariance, and an introduction to quantum theory of scattering and angular momentum.

Johnson

PY 583 Advanced Classical Mechanics I. *Preqs.: MA 512, PY 412, PY 414; grad. standing or permission of the grad. administrator. 3(3-0) F.* An introduction to theoretical physics in preparation for advanced study. Emphasis on classical mechanics, special relativity and the motion of charged particles. Topics include variational principles, Hamiltonian dynamics and the canonical transformation theory, structure of the Lorentz group and elementary dynamics of unquantized fields.

Chung

PY 584 Advanced Classical Mechanics II. *Preqs.: PY 583; grad. standing or permission of the grad. administrator. 3(3-0) S.* Advanced classical mechanics, including continuum mechanics, fields, the group theoretical approach to dynamics and other selected topics.

Katzin

PY 585, 586 Advanced Electricity and Magnetism I, II. *Preqs.: PY 415; grad. standing or permission of the grad. administrator. 3(3-0) F,S.* Topics include: techniques for the solution of potential problems, development of Maxwell's equations; wave equations, energy, force and momentum relations of an electromagnetic field; covariant formulation of electrodynamics; radiation from accelerated charges.

Parker

PY 590 Special Topics in Physics. *Preq.: Consent of department. Credits arranged. F, S.* Investigations in physics under staff guidance. May consist of literature reviews, experimental or theoretical projects or special topics lectures. Graduate Staff

FOR GRADUATES ONLY

PY 601, 602 Theoretical Physics I, II. *Preqs.: PY 583, 586; Coreq.: MA 661. 3(3-0) F, S.* The mathematical and theoretical approach to the relationships between various branches of physics is treated. The restricted theory of relativity, electro-dynamics, classical field theory and the general theory of relativity and geometro-dynamics are considered. Davis

PY 611 Advanced Quantum Mechanics I. *Preqs.: MA 512, PY 582. 3(3-0) F.* An introduction to the relativistic quantum theory of Dirac particles and the positron. Other topics include second quantization technique and its application to many-body problems, radiation theory and the quantization of the electromagnetic field. Cotanch

PY 612 Advanced Quantum Mechanics II. *Preqs.: PY 601, 611. 3(3-0) S.* A general propagator treatment of Dirac particles, photons, and scalar and vector mesons. Applications of Feynman graphs and rules will be given illustrating basic techniques employed in the treatment of electromagnetic, weak and strong interactions. Renormalization theory, the effects of radiative corrections and aspects of the general Lorentz covariant theory of quantized fields also considered. Cotanch

PY 622 Statistical Physics II. *Preq.: PY 521. 3(3-0) F.* A continuation of PY 521, with emphasis on the static and dynamic properties of real (interacting) systems. Topics include the equilibrium theory of fluids and the linear response theory of time-dependent phenomena. Lado

PY (ECE) 627 Semiconductor Thin Films Technology. *3(3-0) S. Alt. yrs.* (See electrical and computer engineering.)

PY 630 Nuclear Structure Physics I. *Preqs.: PY 582; PY 506 or 510. 3(3-0) S.* Advanced description of nuclear models and nuclear reactions. Topics include: internucleon forces, compound-nucleus processes, shell model, optical model, R-matrix theory, direct reactions, collective model, electromagnetic transitions, isobaric analog states. Mitchell

PY 690 Advanced Special Topics in Physics. *Preq.: CI. 1-3 F, S.* Advanced study in astrophysics, atomic and molecular physics, condensed matter physics, nuclear physics or plasma physics. Emphasis on new and rapidly developing research areas. Graduate Staff

PY 695 Seminar. *1(1-0) F, S.* Reports on topics of current interest in physics. Several sections offered so that students with common research interests may be grouped together. Graduate Staff

PY 699 Research. *Credits Arranged.* Graduate students sufficiently prepared may undertake research in some selected field of physics. Graduate Staff

Physiology

GRADUATE FACULTY

Associate Professor J. T. Brake, Coordinator

Professors: R. A. Argenzio, J. H. Britt, E. V. Caruolo, V. L. Christensen, F. W. Edens, C. H. Hill, E. Hodgson, T. E. LeVere, I. S. Longmuir, W. D. Oxender, J. F. Roberts, M. C. Roberts, T. D. Siopes, D. E. Smith, C. E. Stevens, C.-S. Teng, H. A. Underwood Jr.; *Adjunct Professor:* J. P. Thaxton; *Professors Emeriti:* L.

Goode, L. C. Ulberg; *Associate Professors*: B. L. Black, K. L. Esbenshade, R. M. Grossfeld, N. C. Olson, R. M. Petters; *Adjunct Associate Professor*: M. S. Hand; *Assistant Professors*: J. D. Armstrong, H. M. Berschneider, J. E. Gadsby, M. A. Qureshi, R. M. Roe, R. M. Shuman, C. V. Sullivan

Graduate study under the direction of the physiology faculty may lead to the Master of Science, Master of Life Sciences and the Doctor of Philosophy degrees. The physiology faculty is an interdepartmental group drawn from the departments participating in the program. They are animal science, biochemistry, entomology, food animal and equine medicine, poultry science, psychology, (veterinary) anatomy, physiological sciences and radiology and zoology. The program emphasizes the comparative approach implicit in this type of organization.

Experimental facilities of the above departments are available for physiological research, as are such special facilities as the Electron Microscope Center and the Nuclear Service Facility. Experimental animals available cover a wide range, from insects and other invertebrates to large mammals.

In addition to courses in physiology, majors in the program are expected to take selected courses in biochemistry and cell biology. Minors are usually chosen from such fields as biochemistry, entomology, genetics, immunology, veterinary medical sciences, statistics, toxicology and zoology. A strong basic knowledge in one of these areas is essential.

Graduate students enrolled as physiology majors are located in the department of their major professor and may participate in departmental activities.

Prerequisites for admission include a year of physics and organic chemistry, one course in biochemistry and physiology. The Aptitude Test of the Graduate Record Examination is required and the Advanced Tests in biology and chemistry are desirable.

Financial assistance for qualified students in the form of research assistantships, fellowships and traineeships is available through participating departments. Prospective students may obtain further information by writing to any one of the graduate faculty listed above or to the Coordinator, Physiology Program, Box 7608, N. C. State University, Raleigh, North Carolina 27695-7608.

FOR GRADUATES AND ADVANCED UNDERGRADUATES

PHY (ANS) 502 Reproductive Physiology of Vertebrates. 3(3-0) S. (See animal science.)

PHY (ZO) 503 General Physiology I. *Prq.: Sr. or grad. standing; the following courses are recommended: ZO 421 or equivalent, BCH 451 or equivalent, a yr. of physics.* 3(3-0) F. The general principles of homeostasis discussed, emphasizing the importance of integrative action. The following systems studied: muscular, cardiovascular and nervous systems. Grossfeld

PHY (ZO) 504 General Physiology II. *Prq.: PHY (ZO) 503, 3(3-0) S.* The general principles of homeostasis discussed, emphasizing the importance of integrative action. The following systems studied: alimentary, renal, respiratory and endocrine systems. Grossfeld

PHY (ZO) 513 Comparative Physiology. 3(3-0) S. (See zoology.)

PHY (BCH) 553 Physiological Biochemistry. 3(3-0) S. (See biochemistry.)

PHY (MB, PO, VMS) 556 Immunogenetics. 3(2-2) F. (See poultry science.)

PHY (ANS) 580 Mammalian Endocrine Physiology. 3(3-0) F. (See animal science.)

PHY 590 Special Problems in Physiology. *Preqs.: Grad. standing, CI. Credits Arranged. F,S.* Graduate Staff

PHY (ZO) 595 Seminar in Biology of Reproduction. 2(2-0) F. *Alt. yrs.* (See zoology.)

FOR GRADUATES ONLY

PHY (VMS) 632 Comparative Physiology of the Digestive System. 3(3-0) *Every yr.* (See veterinary medical sciences.)

PHY 690 Physiology Seminar. *Preq.: Grad. standing. 1(1-0) S.* Graduate Staff

PHY 695 Selected Topics in Physiology. *Preq.: Grad. standing. 1-4.* Graduate Staff

PHY 699 Physiological Research. *Preqs.: Grad. standing, CI. Credits Arranged. F,S.* Graduate Staff

COURSE FROM ASSOCIATED DEPARTMENTS

BCH 551 General Biochemistry I.

OTHER SUPPORTING COURSES AVAILABLE

Other supporting course are available in biochemistry, biomathematics, entomology, genetics, microbiology, nutrition, poultry science, psychology, statistics, toxicology, veterinary medical sciences and zoology.

Certain courses on the interface between physiology and engineering may be taken after consultation with advisor and the instructors concerned.

Plant Pathology

GRADUATE FACULTY

Professor W. L. Klarman, Head

Professor D. M. Benson, Graduate Studies Coordinator

Professors: J. L. Apple, C. W. Averre III, K. R. Barker, D. F. Bateman, M. K. Beute, E. B. Cowling, C. B. Davey, H. E. Duncan, E. Echandi, G. V. Gooding Jr., L. F. Grand, J. S. Huang, R. K. Jones, M. P. Levi, L. T. Lucas, C. E. Main, R. D. Milholland, J. W. Moyer, D. P. Schmitt, P. B. Shoemaker, T. B. Sutton, H. H. Triantaphyllou, N. N. Winstead; *Professors (USDA):* A. S. Heagle, R. A. Reinert, H. W. Spurr Jr.; *Visiting Professor:* C. S. Hodges Jr.; *Professors Emeriti:* R. Aycock, C. N. Clayton, D. E. Ellis, T. T. Hebert, N. T. Powell, J. P. Ross, J. N. Sasser, D. L. Strider, F. L. Wellman, J. C. Wells; *Associate Professors:* J. E. Bailey, R. I. Bruck, C. L. Campbell, M. E. Daub, W. M. Hagler Jr., B. C. Haning, G. A. Payne, D. F. Ritchie, H. D. Shew, C. G. Van Dyke; *Assistant*

Professors: J. Beagle-Ristaino, P. B. Lindgren, S. A. Lommel, C. H. Opperman;
Assistant Professors (USDA): S. Leath, S. M. Schneider, S. R. Shafer, R. G. Upchurch; *Extension Specialist:* T. A. Melton

Plant pathology has major research programs in disease management, epidemiology, mycology, molecular biology, nematology, virology, biology of soil-borne pathogens, physiology of pathogenesis and general plant pathology. Programs leading to the Master of Agriculture, Master of Life Sciences (both non-thesis), Master of Science and Doctor of Philosophy degrees are offered. Requirements for these three degrees follow University policies: 30 credit hours and thesis for the M.S. degree; 36 for the Master of Agriculture and Master of Life Sciences degrees. The latter afford students an opportunity for general education with a major emphasis in plant pathology course work and subject matter.

Courses and number of hours taken by Ph.D. candidates are determined by the student's interest and background in consultation with an advisory committee. Strong foundation courses in botanical science as well as mathematics, biochemistry, chemistry and soil science are prerequisite, however, for admission to the Ph.D. degree. Students who enroll in any graduate program should have achieved a "B" average in the undergraduate major. A diagnostic examination is utilized in placing incoming Ph.D. students in appropriate graduate courses.

Opportunities for employment include research, extension and teaching appointments at Land-Grant colleges or universities and with the U. S. Department of Agriculture. Agribusiness and biotechnology industries also employs plant pathologists in research, promotion and service. Plant pathologists often participate in overseas assignments in developing countries through international and federal organizations, as well as in commercial enterprises.

Separate laboratories fully equipped and staffed for research in molecular biology, nematology, virology, soil-borne pathogens, physiology of pathogenesis and biochemical problems are available. Microcomputers, library, mycological herbarium, photography laboratory, and an interdepartmental electron microscope center are additional features available in the department. A faculty comprised of more than 50 scientists with varied interests provide for in-depth training in all of these areas.

The department has greenhouse facilities and access to controlled environmental growth chambers in the phytotron. Student participation in the Plant Disease Clinic provides experience in the diagnosis of all types of plant diseases.

North Carolina exhibits a wide range of soil types and climatic areas. Large acreages are planted to a variety of field, vegetable and ornamental crops, as well as forest trees. Special facilities for experimental work on diseases of these crops are found at 16 permanent research stations located throughout the state.

Graduate assistantships are funded by the Agricultural Research Service, the Agricultural Foundation and other agencies. Levels of stipends are adjusted to the previous training and experience of the recipients and are competitive with those offered by other Land-Grant universities. Special supplements to stipends and fellowships are available on a competitive basis for outstanding students.

SELECTED ADVANCED UNDERGRADUATE COURSE

PP 415 Plant Disease Control. *Preq.: PP 315. 3(2-3) S.*

FOR GRADUATES AND ADVANCED UNDERGRADUATES

PP 501 Phytopathology I. *Preq.: PP 315 or equivalent. 5(3-6) F.* Basic concepts and principles of fungal and bacterial plant diseases. Emphasis on history, classification, etiology, pathogenesis, pathogen biology and genetics of host-parasite interaction. Laboratory emphasis on basis methodology of fungal and bacterial plant pathogens and development of an independent research project. Shew

PP 503 Plant Disease Diagnoses. *Preqs.: PP 501 and 502A,B,C or equivalent. 4(2-6) Sum. Alt. yrs.* Diagnoses of plant diseases in the field and laboratory, and operational aspects of a plant disease clinic stressed. Frequent field trips to experiment stations and private farms provide opportunities for field observation of plant disease, plant disease research and diagnosis. Laboratory studies emphasize identification and major sources of descriptive information of plant pathogens and abiotic agents. Grand, Jones

PP 515 Epidemiology and Plant Disease Control. *Preq.: PP 315 or PP 318. 3(3-0) S.* Consideration of fundamental concepts and principles of epidemiology as they apply to modern strategies of plant disease control. Special consideration given to evaluation of current techniques for control of fungal, bacterial, viral and nematode pathogens in an integrated crop protection system. A term paper required to integrate concepts and principles of disease management for a specific crop. Sutton

PP 520 Phytopathology II—Nematology. *Preq.: PP 315 or equivalent. 2(3-6) S.* Lectures and laboratory techniques in plant pathology presented as a series of five-week minicourses. Students may enroll for one or all of the series. Each minicourse consists of lectures on principles and laboratories involving experimental techniques fundamental to the study of nematodes and viruses as plant pathogens and analyses of plant disease epidemics. Taught first 5 weeks of semester. Barker

PP 521 Phytopathology II—Virology. *Preq.: PP 315 or equivalent. 2(3-6) S.* Lectures and laboratory techniques in plant pathology presented as a series of five-week minicourses. Students may enroll for one or all of the series. Each minicourse consists of lectures on principles and laboratories involving experimental techniques fundamental to the study of nematodes and viruses as plant pathogens and analyses of plant disease epidemics. Taught second 5 weeks of semester. Moyer

PP 522 Phytopathology II—Epidemiology. *Preq.: PP 315 or equivalent. 2(3-6) S.* Lectures and laboratory techniques in plant pathology presented as a series of five-week minicourses. Students may enroll for one or all of the series. Each minicourse consists of lectures on principles and laboratories involving experimental techniques fundamental to the study of nematodes and viruses as plant pathogens and analyses of plant disease epidemics. Taught third 5 weeks of semester. Campbell

PP (MB, BO) 575 The Fungi. *3(3-0) F.* (See botany.)

PP (MB, BO) 576 The Fungi—Lab. *1(0-3) F.* (See botany.)

PP 595 Special Problems in Plant Pathology. *Preq.: CI. Credits Arranged, Max. 6.* Investigation of special problems in plant pathology not related to a thesis problem. The investigations may consist of original research and/or literature survey. Graduate Staff

FOR GRADUATES ONLY

PP 604 Morphology and Taxonomy of Nematodes. *Preqs.: PP 502A, CI. 3(1-6) S. Alt. yrs.* A study of the morphology, anatomy and taxonomy of nematodes with emphasis on the identification of important plant-parasitic genera. Exercises include preparation of semi-permanent and permanent nematode mounts. Triantaphyllou

PP 605 Molecular Biology of Plant Viruses. *Preqs.: PP 502B, BCH 451 or 551. 4(2-6) S. Alt. yrs.* An in-depth study of plant viruses with emphasis on the relationship between viral

structure and function. Areas covered include infection, replication, genomic expression, encapsidation and transmission. Laboratory introduces students to contemporary molecular techniques. Lommel

PP 608 History of Phytopathology. *Preqs.: PP 315, CI. 1(1-0) F. Alt. yrs.* Development of the science of phytopathology from its early beginnings to the early part of the 20th century. Campbell

PP 611 Advanced Plant Nematology. *Preqs.: PP 604, 4(3-3) F. Alt. yrs.* Nematode biology, genetics, physiology, molecular biology, ecology, embryogenesis, post-embryonic development, gametogenesis, cytology, reproduction, sexuality, evolution, behavior, host-parasite relationships, mechanisms of pathogenesis and resistance, interactions with other pathogens and impacts on crop performance. Laboratory exercises, research projects and techniques. Barker, Opperman, Triantaphyllou

PP 612 Plant Pathogenesis. *Preqs.: PP 501, BCH 551, BO 551, CI. 3(2-3) F. Alt. yrs.* Infection processes, alterations in photosynthesis, respiration, nitrogen metabolism, vascular function and growth regulator function are considered. The biochemical nature of the weapons utilized by pathogens in pathogenic attack and the defensive mechanisms employed by the hosts in resisting attack and the resultant dynamic interactions are studied. Huang

PP 615 Botanical Epidemiology. *Preqs.: PP 501, 502 or CI; Coreq.: ST 511. 4(2-6) S. Alt. yrs.* Advanced study of the dynamics of plant disease epidemics in relation to agricultural crop production and forestry systems. Emphasis placed upon epidemiological concepts and principles, pathogen and host dynamics, disease forecasting, geographic distribution of pathogens, crop-loss assessment and the development of theoretical and practical disease-management strategies. Bruck, Campbell, Main

PP (CS, GN, HS) 618 Breeding for Pest Resistance. *2(2-0) F. Alt. yrs.* (See crop science.)

PP (BO) 625 Advanced Mycology. *Preq.: PP 575 or CI. 4(2-6) F. Alt. yrs.* An in-depth treatment of major groups of fungi. Aspects of taxonomy, nomenclature, developmental morphology, genetics, host-parasite relations, physiology and ecology presented. Cardinal characteristics of selected fungi representing the major groups determined. Field observations and collecting also required. Grand

PP 628 Soilborne Plant Pathogens. *Preq.: PP 501. 3(2-3) S. Alt. yrs.* An in-depth study of the ecology of soilborne fungal and bacterial pathogens that induce root and wilt diseases in plants. Concepts and principles including but not limited to the rhizosphere, inoculum potential, soil fungistasis, survival, root disease models and biological control. Benson

PP 650 Colloquium in Plant Pathology. *Preq.: PP 502 or CI. 1(1-0) S.* Group discussions and individual presentations explore institutional operations in universities, research laboratories, international centers and industry. Sources of funding through appropriations, research grants and industry cooperators examined. Criteria for evaluating the performance of professional employees, the role of scientific journals and professional societies, as well as public responsibilities considered. Klarman, Graduate Staff

PP 690 Seminar in Plant Pathology. *Preq.: Consent of seminar chairman. 1(1-0) F.S.* Discussion of assigned phytopathological topics. Ritchie

PP 699 Research in Plant Pathology. *Preqs.: Grad. standing, CI. Credits Arranged.* Original research in plant pathology. Graduate Staff

Plant Physiology

GRADUATE FACULTY

Professor R. C. Fites, Coordinator

Professors: F. T. Corbin, J. S. Huang, W. A. Jackson, C. S. Levings III, D. M. Pharr, C. D. Raper, E. C. Sisler, W. F. Thompson, R. J. Volk; *Professors (USDA):* S. C. Huber, D. W. Israel, D. E. Moreland, R. F. Wilson; *Associate Professors:* H. V. Amerson, W. F. Boss, M. M. Peet, S. L. Spiker; *Associate Professor (USDA):* J. M. Anderson; *Assistant Professors:* R. S. Boston, M. A. Conkling, R. Wells; *Assistant Professors (USDA):* K. O. Burkey, T. W. Rufty Jr.

The Plant Physiology Program is an interdepartmental offering. Although not a formal degree program, students may elect to major or minor in the Plant Physiology Program at both the master's and Ph.D. levels. Students entering the program should have appropriate knowledge in plant biology, chemistry, mathematics and physics. Some formal training in genetics, physical chemistry and statistics is normally expected.

When majoring in plant physiology, students will be closely affiliated with the same department as their major professor. As such, they will be required to meet respective departmental requirements for teaching, written and oral examinations, and seminar attendance. Departments currently participating in this program are: biochemistry, botany, crop science, forestry, genetics, horticultural science, plant pathology and soil science. The chair or co-chair of the student's advisory committee must be a member of the Plant Physiology Faculty.

This program is administered by the Plant Physiology Executive Committee. Additional information about the program may be obtained by writing to one of the listed faculty members or to: Coordinator, Plant Physiology Program, Box 7612, North Carolina State University, Raleigh, North Carolina 27695-7612.

Course requirements for this program include two core areas as summarized below. Students majoring in the program are encouraged to develop background training in all of the indicated courses, while those minoring in plant physiology must meet the minimum requirements for each core area.

Group I (At least two of the listed courses)

- BO 510 Plant Anatomy
- BO 551 Advanced Plant Physiology I
- BO 552 Advanced Plant Physiology II

Group II

- BCH 540 Proteins

At least two of the following courses:

- BCH 541 Nucleic Acids
- BCH 542 Metabolism
- or
- BCH 544 Intermediary Metabolism
- BCH 543 Biochemical Regulatory Processes
- BCH 555 Plant Biochemistry

Political Science and Public Administration

GRADUATE FACULTY

Professor M. S. Soroos, Head

Associate Professor H. G. Kebschull, Graduate Administrator for Political Science

Associate Professor D. M. Daley, Graduate Administrator for Public Affairs Program

Professors: E. S. Fairchild, G. D. Garson, A. Holtzman, E. R. Rubin, D. W. Stewart, J. O. Williams; Professors Emeriti: W. J. Block, J. T. Caldwell; Associate Professors: C. K. Coe, R. H. Dorff, J. H. Gilbert, S. H. Kessler, J. P. Mastro, J. M. McClain, E. O'Sullivan, J. E. Swiss, M. L. Vasu; Associate Professor Emeritus: K. S. Petersen; Assistant Professor: T. V. Reid; Visiting Assistant Professor: G. C. Sims; Lecturer: J. B. Rosch

The Department of Political Science and Public Administration offers programs leading to the Master of Public Affairs degree and the Master of Arts degree.

A candidate for admission to either program must have demonstrated an aptitude for graduate study as indicated by the Graduate Record Examination; the student may also be required to take certain undergraduate courses to make up any deficiencies that may exist in the undergraduate record.

The Master of Public Affairs degree requires completion of a 41-semester-hour professional program for persons who are now or hope to be employed by government or by a government-related private enterprise or association. An internship in a government agency is required for persons with no previous public sector experience.

The program requires 31 hours to be selected from courses offered by the Department of Political Science and Public Administration, including 16 hours of core courses. Students may specialize in financial management, human resource management, data management, association/non-profit management, urban management, environmental resources management or administration of justice. The remaining hours may be taken in another discipline, such as economics and business, education, industrial engineering, psychology, recreation, sociology and statistics, or as an interdisciplinary sequence of courses.

Students who enroll in the program should have completed twelve hours in the social sciences as undergraduates and have achieved a B average in the last two years of school. PA 571, a core course, has a statistics prerequisite.

The Master of Arts degree requires each candidate to complete 30 hours of graduate work including three hours in Research Methods and Analysis (PS 571). The candidate must concentrate (18-21 hours, including thesis) in two major fields of political science. Major fields are to be selected from the following: political theory, American politics, comparative politics, international relations and public administration. A disciplinary minor of 9 to 12 hours outside the Department of Political Science and Public Administration is required. A stu-

dent's work in a minor field must constitute a unified pattern and must contribute to one or both of the student's major fields.

In either program the student selects a graduate committee chairperson for the preparation of a program of study which shall be subject to the approval of two other committee members, including one from outside the Department of Political Science and Public Administration.

Comprehensive written and oral examinations are required of every candidate for both degrees. In addition, a candidate for the Master of Arts degree must demonstrate reading proficiency in one modern language (normally German, French, Spanish or Russian) or a research skill and must write a thesis in one of his or her major areas.

SELECTED ADVANCED UNDERGRADUATE COURSES

PS 401 American Parties and Interest Groups. 3(3-0) F.

PS 402 Campaigns and Elections in the American Political System. *Preq.: PS 201.* 3(3-0) F,S.

PS 406 Politics and Policies of American State Governments. 3(3-0) F,S,Sum.

PS 408 Urban Politics. 3(3-0) F,S.

PS 411 Public Opinion and the Media. *Preq.: Six hrs. of social science.* 3(3-0) S.

PS 431 International Law and Organization. 3(3-0) F.

PS 437 National Security Policy. *Preq.: PS 331.* 3(3-0) S,Sum.

PS 446 Comparative Communist Systems. *Preq.: PS 344 or 332.* 3(3-0) F,S.

PS 447 Political Development. *Preq.: Six hrs. of PS.* 3(3-0) F. Alt. yrs.

PS 462 Seminar in Political Theory. *Preq.: PS 361.* 3(3-0) S.

PS 498 Special Topics in Political Science. *Preq.: Six hrs. of PS.* 3-6 F,S.

FOR GRADUATES AND ADVANCED UNDERGRADUATES

PA 505 Administrative Law. *Preq.: Grad. standing or PBS status.* 3(3-0) S. Case law of the exercise of administrative power, judicial and legislative control of administrative action, legal rights of public employers and legal procedures of administrative tribunals.
McClain

PA 511 Public Administration. *Preq.: Advanced undergrad. standing including 12 hrs. in PS, grad. standing or PBS status.* 3(3-0) F,S,Sum. A general survey of the field of public administration, examining formal and informal organizations, processes of administration, the political environment of administration and administrative responsibility and accountability.
Graduate Staff

PA 513 Financial Management in the Public Sector. *Preq.: Grad. standing or PBS status.* 3(3-0) F. This course surveys financial practices and concepts in the public sector. Topics include: public sector accounting, financial information systems, revenue projections, cash management and debt management. Case-based applications emphasized.

Coe

PA 515 Administration of Criminal Justice. *Preq.: Advanced undergrad. standing including 12 hrs. of PS, grad. standing or PBS status. Credit for both PS 415 and PA 515 is not allowed. 3(3-0) F.* A study of politics and administration in the American criminal justice system. The interrelationships between ideology, organization and policy outputs emphasized in the analysis of major problems confronting the system today. Topics included: intergovernmental relations, discretionary justice, impact of judicial decisions on criminal justice administration and management trends in criminal justice bureaucracies.

Fairchild

PA 516 Public Policy Analysis. *Preq.: Advanced undergrad. standing including 12 hrs. of PS, grad. standing or PBS status. 3(3-0) F,S,Sum.* Course covers methods and techniques of analyzing, developing and evaluating public policies and programs. Emphasis given to benefit-cost and cost-effectiveness analysis and concepts of economic efficiency, equity and distribution. Methods include problem solving, decision making and case studies. Examples used in human resource, environmental and regulatory policy.

Swiss

PA 518 Organization Design. *Preq.: Advanced undergrad. standing including 12 hrs. of PS, grad. standing or PBS status. 3(3-0) S.* An examination of contemporary approaches to organization design, including organization development, sociotechnical systems analysis and various forms of organizational participation ranging from human relations to self-management models. Issues in personnel administration emphasized in relation to public management and government structure.

Graduate Staff

PA 520 Environmental Policy. *Preq.: Advanced undergrad. standing including 12 hrs. of PS, grad. standing or PBS status. 3(3-0) F.* This course focuses on the formation and impact of environmental policy in the United States. Decision-making processes at all levels of government examined. Comparisons made between political, economic, social and technological policy alternatives. Emphasis given to the application of policy analysis in environmental assessment, and theoretical perspectives on the nature of the environmental crisis considered.

Graduate Staff

PA 570 Research Methods Computing Lab. *Preqs.: Advanced undergrad. standing including 12 hrs. of PS, grad. standing or PBS status and an introductory course in ST. 1(0-2) F,S.* A one-hour computing lab that complements the public administration curriculum. Introduction to computing on both mainframe and microcomputer. Includes TSO/QED statistical packages, SPSS data structures and microcomputing software.

Graduate Staff

PA 571 Research Methods and Analysis. *Preqs.: Advanced undergrad. standing including 12 hrs. of PS, grad. standing or PBS status and an introductory course in ST. 3(3-0) F,S.* A focus on the behavioral approach to the study of political and administrative behavior. Topics include the philosophy of social science; experimental, quasi and non-experimental research design; data collection techniques; basic statistical analysis with computer applications.

O'Sullivan, Vasu

PA 573 Computer Applications in Public Affairs. *Preqs.: ST 507; CSC 462 or PS 371 or PA 571. 3(1-6) S,Sum.* The methodology, data analysis techniques and computer-based skills necessary to conduct and manage applied research. The course focuses on the analysis and processing of data through the medium of conventional computer software frequently used in the field, i.e., SPSS, SAS.

Graduate Staff

PA 574 Data Management in Public Administration. *Preqs.: PS 374 or PA 573 and previous coursework or experience in public administration. 3(3-0) S.* An introduction to managerial applications of data management in public budgeting, public personnel and public policy analysis. Microcomputers used to construct data bases and analytic models in these areas.

Garson

PA 580 Independent Study. *Preq.: Grad. standing or PBS. 1-6. F,S,Sum.* Independent research or readings by graduate students under the direct supervision of individual

faculty members. Students' work evaluated, based on reports, papers and exams, with letter grading (A, B, C, D, NC) employed. Graduate Staff

PA 590 Readings and Research. *Preq.: Grad. standing. 1-3 F,S,Sum.* To enable graduate students to pursue a subject of particular interest to them by doing extensive readings or research in that subject under direct, individual faculty supervision. Graduate Staff

PA 598 Special Topics in Public Administration. *Preq.: Advanced undergrad. standing including 12 hrs. in PS, grad. standing or PBS status. 1-6 F,S,Sum.* Detailed investigation of contemporary topics in the fields of public administration. Topic and mode of study determined by program faculty. Graduate Staff

PS 502 The Legislative Process. *Preq.: Advanced undergrad. standing including 12 hrs. of PS, grad. standing or PBS status. 3(3-0) S.* A study of the formulation of public policy from the institutional and behavioral viewpoints. Important current legislative problems at the congressional and state legislative levels will be selected and will serve as a basis for analyzing the legislative process. Holtzman

PS 506 American Constitutional Theory. *Preq.: Advanced undergrad. standing including 12 hrs. of PS, grad. standing or PBS status. 3(3-0) F.* Basic constitutional doctrines, including fundamental law, judicial review, individual rights and political privileges and national and state power. Special attention given to the application of these doctrines to the regulation of business, agriculture and labor and to the rights safeguarded by the First, Fifth and Fourteenth Amendments to the Constitution. Rubin

PS 507 Constitutional Theory II. *Preq.: Advanced undergrad. standing including 12 hrs. of PS, grad. standing or PBS status. 3(3-0) F,S.* A continuation of PS 506, but may be elected separately. An examination of leading constitutional cases, especially in the fields of civil liberties and individual rights and the writings of leading commentators. Reid, Rubin

PS 514 Public Finance. *Preq.: EB 205. 3(3-0) F.* A survey of the theories and practices of governmental taxing, spending and borrowing, including intergovernmental relationships and administrative practices and problems. Graduate Staff

PS 531 International Law. *Preq.: Grad. or advanced undergrad. standing. 3(3-0) Every yr.* Sources and subjects of international law, domestic and international jurisdictions, judicial settlement, legal and illegal uses of force and the substance of law in selected policy areas. Graduate Staff

PS 533 Global Problems and Policy. *Preq.: Advanced undergrad. standing including 12 hrs. of PS, grad. standing or PBS status. Credit for both PS 433 and PS 533 is not allowed. 3(3-0) F.* International policy processes and policy responses to problems of global scope including the role of international law. Consideration given to economic development, human rights and other policy problems selected for specific semesters. Independent research on a global policy problem of student's choice. Soroos

PS 541 Military Coups and Regimes in the Third World. *Preqs.: Advanced undergrad. standing, grad. standing or PBS status. 3(3-0) F.* The seizure and exercise of political power by military forces in Asia, Africa and Latin America. Causes and techniques of military coups, with emphasis on the social, economic and political policies of military regimes. Case studies within the context of theories about the political role of the military. Kebschull

PS 542 Western European Politics. *Preq.: Nine hrs. of PS, grad. standing or PBS status. Credit in both PS 442 and PS 542 is not allowed. 3(3-0) F.* Analysis of political institutions and processes in selected Western European states and the European community and of major social, economic and political issues confronting European societies. Kebschull

PS 545 Comparative Systems of Law and Justice. *Preq.: grad. standing. Credit in both PS 445 and PS 545 is not allowed. 3(3-0) F,S.* A study of legal culture and administration of justice in Western European, Third World and Communist political systems, with a view to

comparison with the American system of law and justice. Emphasis on the impact of legal ideology on such topics as the nature of crime, political justice, police administration, corrections and judicial processes. Fairchild

PS 571 Research Methods and Analysis. *Preqs.: Advanced undergrad. standing including 12 hrs. of PS, grad. standing or PBS status. 3(3-0) F,S.* A survey of methods used in behavioral research as applied to the field of political science: elements of empirical theory, research design, measurement of variables, sampling procedures, data courses, techniques of data collection, statistical analysis, qualitative methodologies and the presentation of research findings. Soroos, Vasu

PS 590 Readings and Research. *Preq.: Grad. standing or PBS status. 1-3 F,S,Sum.* Graduate students pursue a subject of particular interest to them by doing extensive readings or research in that subject under direct, individual faculty supervision. Graduate Staff

PS 598 Special Topics in Political Science. *Preq.: Six hrs. of PS. 1-6 F,S.* Detailed investigation of a topic. Topic and mode of study determined by the student and a faculty member. Graduate Staff

FOR GRADUATES ONLY

PA 608 Seminar in Urban Management. *Preqs.: Grad. standing or Management Development Certificate Program and six hrs. of 500-level course work. 3(3-0) F.* A seminar focusing on the analytical techniques and managerial principles required for policy formation and implementation in a complex urban governmental environment. Specific topics include: urban planning and community development, housing, intergovernmental relations, organizational roles and decision making, budgeting and selected urban services (for example: police, transportation). Graduate Staff

PA 611 Seminar in Public Personnel Management. *Preqs.: Grad. standing or Management Development Certificate Program and six hrs. of 500-level course work. 3(3-0) F,S.* Examines the major issues in public sector personnel management. Among topics considered: staffing, position classification, compensation, affirmative action, performance review and appraisal, patronage, training, career development, employee assistance, unionization and rights of public employees. Daley, Sims

PA 612 The Budgetary Process. *Preqs.: Grad. standing or Management Development Certificate Program and six hrs. of 500-level course work. 3(3-0) F,S,Sum.* This course examines generalized budgetary process used at all levels of government in the United States. Understanding of the process based upon comprehension of the institutions involved, the roles of politicians and professionals and the objectives of budgetary systems. The course also focuses upon budgetary reforms and on Planning-Programming-Budgetary and Zero-Based Budgeting as management tools. Coe

PA 613 Government and Planning. *Preqs.: Grad. standing or Management Development Certificate Program and six hrs. of 500-level course work. 3(3-0) F,Sum.* A study of the planning function at all levels of government in the United States, with particular attention to the problems posed for planning by the rapid growth of metropolitan areas. An overview of community development, urban spatial structure, housing economics and land use planning. Vasu

PA 614 Management Systems. *Preqs.: Grad. standing or Management Development Certificate Program and six hrs. of 500-level course work. 3(3-0) S,Sum.* An examination, through case studies and applied methodology, of various management systems and management techniques. Among the topics considered: differences between market and non-market organizations, financial management systems, quantitative decision-making approaches, planning techniques such as CPM and PERT, MBO and productivity systems. O'Sullivan, Swiss

PA 616 Seminar in Program Evaluation. *Preqs.: Grad. standing or Management Development Certificate Program and a grad. course in research methods. 3(3-0) F,S.* The course combines seminar and field research techniques to study the evaluation of public programs. Focus on political and administrative problems associated with program evaluation. The availability and appropriateness of various quantitative methodologies also examined. Seminar concepts applied through evaluative projects conducted for public agencies.
O'Sullivan

PA 617 Seminar in Organization Theory. *Preqs.: Grad. standing or Management Development Certificate Program and six hrs. of 500-level course work. 3(3-0) F,S.* The seminar examines major conceptual frameworks developed to understand organizational behavior. Topics stressed include motivation, leadership, group dynamics, communication, socio-technical systems, work design and organizational learning. The emphasis on applying theories and concepts to public sector organizations.
Daley, Vasu

PA 619 Intergovernmental Relations in the United States. *Preqs.: Grad. standing or Management Development Certificate Program and six hrs. of 500-level course work. 3(3-0) S.* The course examines distinctive features of intergovernmental relations in the United States. Topics stressed include historical adaptations of federalism, the emerging role of the administrator, contemporary trends in intergovernmental relations and assessment of contemporary trends from federal, state and local perspectives.
Coe

PA 620 Environmental Administration. *Preqs.: Grad. standing or Management Development Certificate Program and six hrs. of 500-level course work. 3(3-0) S.* A review and investigation of the major environmental management systems utilized to plan, develop and implement environmental programs.
Graduate Staff

PA 621 Collective Negotiations in the Public Service. *Preqs.: Grad. standing or Management Development Certificate Program and six hrs. of 500-level course work. 3(3-0) Sum.* This course includes intensive consideration of the background of the collective negotiations movement; analysis of key policy issues, such as bargaining rights and the use of strike weapons; framework for collective negotiations; scope and conduct of negotiations; impasse resolution; grievance procedure.
Graduate Staff

PA 691 Internship in Public Affairs. *Preq.: Minimum 9 hrs. graduate work. 1-6 F,S,Sum.* This course exposes the student to the environment and value systems of the public organization through a supervised work experience. It involves the application of substantive knowledge and analytical skills to organizational problems. Credit will vary with the nature of the work experience.
Graduate Staff

PS 631 Seminar in International Relations. *Preq.: Six hrs. of 500-level course work. 3(3-0) F,S,Sum. May be taken for up to six hours credit.* An in-depth examination of a topic within the larger field of international politics to be selected by the instructor for each semester from subjects pertaining to interstate relations, international law and organization, regional politics, foreign and security policy or global issues. Students undertake a substantial independent research project.
Soroos

PS 641 Seminar in Comparative Politics. *Preqs.: One course in comparative politics and one course in PS methodology or CI. 3(3-0) F,S.* This seminar opens with a survey of the problems and methods of comparative political analysis, after which students assigned a specific, limited subject to be examined within the framework of a systematic, analytical scheme appropriate to the topic. Specific topics drawn from the subjects of political ideologies, political groups, political elites and decision-making institutions and processes.
Kebschull

PS 691 Internship in Political Science. *Preq.: Grad. standing. 1-6 F,S,Sum.* This course exposes the student to the environmental and value systems of public organizations through a supervised work experience.
Graduate Staff

PS 696 Seminar in Politics. *Preq.: Advanced grad. standing. 2-4 F,S.* An independent advanced research course in selected problems of government and politics. The problems chosen in accordance with the needs and desires of the students registered for the course.
Graduate Staff

PS 699 Research in Politics. *Preqs.: Grad. standing and approval of adviser. Credits Arranged. F,S.* Research for writing the master's thesis.
Graduate Staff

Poultry Science

GRADUATE FACULTY

Professor G. B. Havenstein, Head

Professors: J. T. Brake, T. A. Carter, V. L. Christensen, R. E. Cook, W. E. Donaldson, F. W. Edens, J. D. Garlich, P. B. Hamilton, C. H. Hill, F. T. Jones, C. R. Parkhurst, J. C. H. Shih, T. D. Siopes; *Adjunct Professors:* D. I. McRee, J. P. Thaxton; *Professors Emeriti:* E. W. Glazener, J. R. Harris; *Associate Professors:* J. B. Carey, W. M. Hagler Jr., J. F. Ort; *Assistant Professors:* P. R. Ferket, M. A. Qureshi, D. V. Rives, S. E. Scheideler, R. M. Shuman; *Adjunct Assistant Professors:* R. P. Gildersleeve, J. W. Laskey

ASSOCIATE MEMBERS OF THE DEPARTMENT

Professor; H. R. Ball Jr.; *Associate Professors:* W. J. Croom Jr., B. W. Sheldon

The Department of Poultry Science offers the Master of Science degree. Doctoral programs are offered in the disciplines of microbiology, physiology, genetics and nutrition.

The department occupies Scott Hall, containing well-equipped laboratories, animal rooms and offices. Additional research facilities are located on the University farms and the Piedmont Research Station.

The Dearstyne Avian Research Center, a three-building complex, is used in connection with special research projects related to disease resistance and treatment of various pathological conditions. The complex is made up of animal isolation rooms, biochemical laboratories and related facilities.

The research program is comprehensive and includes fundamental studies in genetics, microbiology, nutrition, pathology, immunology, molecular biology, toxicology and physiology. In addition, investigation of problems of more practical urgency is undertaken when appropriate.

The demand for men and women with advanced training in poultry science is far greater than the supply. Opportunities exist for graduates in research and teaching in universities, in government and in private industry.

SELECTED ADVANCED UNDERGRADUATE COURSES

PO 405 Avian Physiology. *Preq.: CH 220. 4(3-3) F.*

PO 410 Production and Management of Game Birds in Confinement. *Preq.: PO 201. 3(2-3) S.*

PO (ANS, NTR) 415 Comparative Nutrition. *Preqs.: CH 220 or both 221 and 223. 3(3-0) F.*

FOR GRADUATES AND ADVANCED UNDERGRADUATES

PO 505 Physiological Aspects of Poultry Management. *Preqs.: PO 201, PO 405 or grad. standing. 3(3-0) S.* Application of physiological principles to modern poultry management. Poultry physiology related to management topics including nutrition, housing, ventilation, disease, heat stress and lighting programs. Brake

PO (GN) 520 Poultry Breeding. *Preq.: GN 411. 3(2-2) S.* Application of genetic principles to poultry breeding, considering physical traits and physiological characteristics. Shuman

PO (ZO) 524 Comparative Endocrinology. *Preq.: ZO 421 or equivalent. 4(3-3) S.* Basic concepts of endocrinology, including functions of major endocrine glands involved in processes of growth, metabolism and reproduction. Siopes

PO (MB, PHY, VMS) 556 Immunogenetics. *Preq.: MB 501C or MB 551 or CI. 3(2-2) F.* Basic concepts of the immune system. Genetic basis of the immune response including immunoglobulin genetics, major histocompatibility complexes and their role in the immune response, the molecular basis of the immune system and effector mechanisms. Qureshi

PO 590 Graduate Seminar in Poultry Science. *1(1-0) F.* Preparation for research, research perspectives, rising concerns in poultry production, orientation for graduate studies in poultry science. Required of all graduate students in the Department of Poultry Science. Graduate Staff

FOR GRADUATES ONLY

PO (ANS, NTR) 605 Mineral Metabolism. *3(3-0) F.* (See animal science.)

PO 698 Special Problems in Poultry Science. *Preq.: Grad. standing. Maximum 6 F,S.* Specific problems of study assigned in various phases of poultry science. Graduate Staff

PO 699 Poultry Research. *Preq.: Grad. standing. Credits Arranged. A max. of six credits is allowed towards a master's degree. F,S.* Appraisal of present research; critical study of some particular problem involving original investigation. Problems in poultry breeding, disease, endocrinology, hematology, microbiology, nutrition or physiology. Graduate Staff

Product/Visual Design

GRADUATE FACULTY

Professor H. Khachatoorian, Program Director

Professors: V. M. Foote, A. S. Lowrey; Professors Emeriti: G. L. Bireline Jr., J. H. Cox; Associate Professors: A. V. Cooke, R. A. Donaldson, C. E. Joyner, M. S. Lange, P. L. Middleton, S. D. Wilchins, J. M. Wittkamp; Assistant Professors: S. K. Ater, D. S. Chapin

The Department of Product/Visual Design offers courses of study leading to a Master of Product Design degree with three distinct concentrations: Product Design, Visual Design and Textile Design.

Product design deals with all aspects of machine-made products and their relationship to people and the environment. The discipline therefore involves three major research and design activities: human behavior, the human/product relationship and the product itself. In the School of Design's Product Design curriculum, the emphasis is on the designer's responsibility in enhancing the quality of human life. Students learn to consider all the effects of a product, from its conception through production, and eventually its use.

The graduate curriculum prepares students for professional careers in product research, development and design. Core and elective courses focus on problem identification, problem-solving methods, communication skills and the nature of materials and production processes.

In the studio, students use this knowledge to solve real-world design problems requiring research, creativity and the application of newly acquired technical skills. Work on these projects helps students consider essential design factors such as form, safety, physiology, materials/manufacturing processes, color, texture, cost and maintenance.

Graduates of the Product/Visual Design Department are working in a variety of fields, including furniture, housewares, appliances, transportation, machine tools, medical and electrical instruments and microelectronics. In addition, the department offers many opportunities for 'co-op' and internship educational programs, which combine academic coursework with valuable on-the-job experiences.

Students in the Visual Design curriculum learn to graphically communicate information, concepts and feelings through various media, especially print. Classes in graphic design history, typography, photography, illustration, printing processes and materials are synthesized with theory and methodology in the studio.

The graduate curriculum prepares students to apply their creativity and technical expertise in either professional or non-applied academic research. Professional situations include the study of signs and symbols, posters, book and magazine design, packaging, exhibits, advertising and computer graphics. The academic orientation of study involves investigations of communication theory, problem-solving methodologies, form-generating strategies, visual perception and design evaluation.

Textile design is the creation and development, by hand or machine, of fiber and fiber objects. While fabric yardage immediately comes to mind, textile designers also create clothing and accessories, home furnishings, wall hangings and other textiles for specific architectural or environmental purposes.

In all these areas, the textile designer must combine creative ability and technical skills to conceive a product that is aesthetically pleasing, functionally sound and appropriate for production. This requires a thorough understanding of production processes, including product research, development and design; basic management principles and structures; marketing, manufacturing and merchandising. Students pursue study in specific areas of textile design, including printing, weaving, knitting, design and production processes. Whether the interest is in industrial mass production or individual craftsmanship in tradi-

tional methods of fabric construction, the same emphasis is placed on high quality design and how textiles shape, alter and enhance the human environment.

In the graduate program, students earn the professional Master of Product Design, with a Textile Design concentration.

The student's program of selected course work and terminal project are under the direction of his/her graduate advisory committee. The terminal project shall constitute the final test of the candidate's mastery of his/her design studies. The project shall be developed in the design studio or special projects framework in the final year and shall consist of an in-depth investigation of an approved problem, which relates product design studies to the student's minor field. All students with a five-year undergraduate degree, equivalent or professional experience shall be required to complete a minimum of 30 hours of course work of which approximately 70 percent will be in the major field and the remainder elected from various specialized knowledge areas.

For students holding four-year undergraduate degrees in design, the program requires a minimum of 48 credit hours of course offerings in the normal two-year master's work.

Applications for this program may come from the following sources: graduates of approved schools of product design, graduates of approved programs of industrial design, graduates of approved schools of graphic design, graduates of accredited schools of architecture or landscape architecture, graduates of approved schools of art and design, graduates of accredited schools of engineering and, under special circumstances, students with degrees in fields other than design. In those latter instances an advisory committee will evaluate the applicant's preparation with regard to design capabilities and professional competence. In addition, course offerings are available to any graduate student who can demonstrate reasonable competence or equivalent qualifications for prerequisites in the requested courses. All applicants in addition to meeting the qualifications of the Graduate School must meet the special requirements of the Product Design program with regard to design capabilities and professional competence.

SELECTED ADVANCED UNDERGRADUATE COURSES

PD 400 Product Design Studio. *Preq.: DF 102 or written approval of dept. head. 6(0-9) F,S.*

PD (TX) 471 Textile Design Studio. *Preqs.: A grade of C or better in PD (TMT) 272, 371 and 372. 6(0-9) F,S.*

VD 400 Visual Design Studio. *Preq.: DF 102 or written approval of dept. head and dean; Coreq.: DN 456, DN 242. 6(0-9) F,S.*

FOR GRADUATES AND ADVANCED UNDERGRADUATES

PD 510 Product Design Project Preparation. *Preq.: Grad. standing. 3(3-0) S.* A seminar course designed to assist students in preparing the groundwork for the final project to be conducted in the design studio.

PD 511 Product Design Materials and Processes I. *Preq.: Grad. standing. 3(3-0) F.* An analysis of paper, wood, metal and manufacturing processes utilized in the production of mass-produced products. Advanced studies in mass production processes and their influ-

ence on design and development of products. Emphasis placed on material search and process selection in relation to product safety, cost, function, human factors, form, finishes and joining methods.

PD 512 Product Design Materials and Processes II. *Preq.: Grad. standing. 3(3-0) S.* An analysis of plastics and rubber and the related manufacturing processes utilized in the production of mass-produced products. Advanced studies in mass production processes and their influence on design and development of products. Emphasis placed on material search and process selection in relation to cost, product safety, function, human factors, form, finishes and joining methods.

PD 541, 542 Advanced Visual Design I, II. *Preqs.: ARC 400, LAR 400, PD 400 or VD 400; waiver of req. is at the discretion of the instructor. 6(3-9) F,S.* Application of previous studies in design and visual communications to a wide variety of visual problems presented by our physical environment.

PD 591 Special Seminar in Product Design. *Preq.: Grad. standing. 1-3 F,S.* Seminars on subjects of current interest in product design which are presented by persons not part of the regular faculty.

PD 592 Special Topics in Product Design. *Preq.: Grad. standing. 2-3 F,S.* Topics of current interest to the program/option offered by faculty in the School. Subjects offered under this number normally used to test and develop new courses.

PD 595 Independent Study in Product Design. *Preq.: Grad. standing. Max. 6. F,S,Sum.* Special problems in various aspects of product design developed under the direction of a faculty member on a tutorial basis.

VD 510 Visual Design Project Preparation. *Preq.: BEDVD degree or equivalent. 3(3-0) S.* A seminar course designed to assist students in preparing the foundation for the final project to be conducted in the design studio.

VD 517 Advanced Typographic Systems. *Preqs.: DN 217 and DN 317. 3(2-2) F.* Systematic approaches to structuring typographic form according to information hierarchies, user needs and visual expression. Application to the organization of tables, charts, books, magazines, corporate identities and signage.

VD 518 Advanced Typographic Expression. *Preqs.: DN 217 and DN 317 or equivalent. 3(2-2) S.* This course focuses on experimentation in typography for the purpose of subjective expression. Analysis of historical precedent, contemporary usage and the semiotics of shaped writing provide a basis for the advanced student to study and use typography as image, metaphor and symbol.

VD 519 Non-camera Photographics. *Preqs.: VD 218, VD 256, VD 400. 3(2-2) S.* Image-making using photographic materials but not the camera. Exercises and projects emphasize the integration of these images with typography and graphic elements. Processes include diazo, photograms and xerography. Application to practical graphic design problems.

VD 591 Special Seminar in Visual Design. *Preq.: Grad. standing. 1-3 F, S.* Seminar on subjects of current interest in graphic design, presented by persons not part of the regular faculty.

VD 592 Special Topics in Visual Design. *Preq. Grad. standing. 2-3 F, S.* Topics of current interest to the program/option offered by faculty in the School. Subjects offered under this number normally used to test and develop new courses.

VD 595 Independent Study in Visual Design. *1-3 F,S,Sum.* Special problems in various aspects of graphic design developed under the direction of a faculty member on a tutorial basis.

FOR GRADUATES ONLY

PD 600 Advanced Product Design (Series). *Preq.: Portfolio review. 6(0-12) F,S.* Advanced studies in product design. Special emphasis is given to problem identification, program formulation and application of advanced design methods. All problems will be of an individual nature leading to a synthesis of previous design experience.

PD 632 Advanced Concepts in Product Engineering. *Preqs.: PD 600, grad. standing. 3(3-0) F,S.* Group investigation of advanced concepts in product design with emphasis on engineering. Engineering principles play an important role in the design of useful products. The scope of this course includes mass movement of persons as well as the designs of consumer products. The field of transportation and consumer products are fast-changing to satisfy the needs of present and future generations. The product designer to be made aware of these needs by special investigations into future technologies and material developments.

PD 670 Advanced Product Design-Textiles (Series). *Preq.: Portfolio review. 6(0-12) F,S,Sum.* Advanced studies in textile styling. Special emphasis given to problem identification, program formulation and application of advanced design methods. All problems of an individual nature.

PD 691 Special Topics in Product Design. *Preq.: Grad. standing. 1-6 S.* An investigation of special topics in product design of a particular interest to advanced students under the direction of the chair of the graduate committee on a tutorial basis. Credit and content vary with each student.

PD 698 Final Project Studio in Product Design. *Preq.: 18 hours of PD 600. 6(0-12).* Final project for graduate students supervised by members of their graduate advisory committees.

VD 600 Advanced Visual Design (Series). *Preq.: Portfolio review. 6(0-12) F,S,Sum.* Advanced studies in graphic design. Special emphasis given to problem identification, problem formulation and application of advanced design methods. All problems of an individual nature leading to a synthesis of previous design experiences.

VD 691 Special Topics in Visual Design. *Preq.: Permission of grad. advisor. 1-6 F,S,Sum.* An investigation of special topics in graphic design of a particular interest to advanced students under the direction of the chair of the graduate committee on a tutorial basis; credit and content vary with each student.

VD 698 Final Project Studio in Visual Design. *Preq.: 18 hrs. of VD 600. 6(0-12) F,S.* Final project for graduate students supervised by members of their graduate advisory committees.

Psychology**GRADUATE FACULTY**

Professor P. W. Thayer, Head

Professors: J. W. Cunningham, D. W. Drewes, T. E. LeVere, S. E. Newman, B. W. Westbrook; Adjunct Professor: J. L. Howard; Professors Emeriti: K. L. Barkley, H. M. Corter, J. C. Johnson, H. G. Miller; Associate Professors: J. L. Cole, D. O. Gray, T. M. Hess, P. E. Horan, J. W. Kalat, K. W. Klein, J. E. R. Luginbuhl, D. H. Mershon, S. B. Pond III, F. J. Smith, S. S. Snyder, N. W. Walker; Adjunct Associate Professor: B. F. Corder; Associate Professors Emeriti: M. H. Pitts, R. F. Rawls; Assistant Professors: L. E. Baker-Ward, M. Y. Bingham, S. A.

Converse, W. P. Erchul, R. W. Nacoste; *Visiting Assistant Professor*: B. A. Braddy; *Adjunct Assistant Professors*: B. H. Beith, A. D. Hall, C. L. Kronberg

ASSOCIATE MEMBERS OF THE DEPARTMENT

Professors: C. D. Korte, R. G. Pearson, J. L. Wasik

The Department of Psychology offers seven courses of study leading to the Doctor of Philosophy degree. Specialization is available in applied developmental psychology, experimental psychology, ergonomics, industrial-organizational and vocational psychology, school psychology, social psychology and human resource development. The Master of Science degree is awarded as part of a student's work toward the doctorate at NCSU.

A minimum of 30 semester hours of graduate credit is required for the master's degree. Though no minimum number of additional hours is required for the doctoral degree, the student may expect to take 30 or more additional semester hours of graduate credit. The actual graduate program for each student is tailored to the needs, interests and accomplishments of the individual. Admission requirements for the beginning graduate student in psychology are satisfactory grades in all undergraduate work and at least a "B" average in undergraduate psychology courses and in the undergraduate major, satisfactory scores on the Graduate Record Examination including the Advanced Test in psychology and three satisfactory letters of recommendation in regard to quality of work and character. The Miller Analogies Test is recommended as well. It is possible to enter the program without undergraduate coursework in psychology but some preparation in experimental psychology, statistics and mathematics is desirable.

Admission requirements for students already possessing the master's degree who wish to obtain the doctorate in psychology are a minimum of a "B" average in their graduate work and a substantial background in psychology or related fields, satisfactory grades in undergraduate studies, satisfactory scores on the Graduate Record Examination including the Advanced Test in psychology (if the applicant's master's degree is in a field other than psychology, the Advanced Test score in that field should also be submitted) and three satisfactory letters of recommendation in regard to quality of work and character. The Miller Analogies Test is also recommended.

Match of applicants' proposed research interests with those of current faculty is an important criterion for admission.

A limited number of research and teaching assistantships and fellowships are available to qualified graduate students.

SELECTED ADVANCED UNDERGRADUATE COURSES

PSY 476 Psychology of Adolescent Development. *Preq.: PSY 200 or PSY 304. 3(3-0) F,S,Sum.*

PSY 491 Special Topics in Psychology. *Preq.: PSY 200. 3(3-0) F,S.*

FOR GRADUATES AND ADVANCED UNDERGRADUATES

PSY 500 Visual Perception. *Preq.: Grad. standing or CI. 3(2-2) F.* Detailed consideration of anatomy and physiology of the visual system (both peripheral and central components). Modern quantitative approaches to psychophysical problems of detection, discrimination, scaling. Examination of chief determinants of visual perception, including both stimulus variables and such organismic variables as learning, motivation and attention. Discussion of perceptual theory and processes emphasizes several topics in two- and three-dimensional spatial perception. Mershon

PSY 501 Introduction to Graduate Study in Psychology. *Preq.: Grad. standing in PSY. 1(1-0) F.* Orientation to graduate study in psychology. Library and computer systems. Faculty research and teaching interests. Special research facilities and populations. Standards for research with human and infrahuman subjects. Ethical principles of American Psychological Association. Generic and specialty guidelines for providers of psychological services. North Carolina Licensing Law and supporting rules. Psychology as science, discipline and profession. Newman

PSY 502 Physiological Psychology. *Preq.: Twelve hrs. of PSY including PSY 200, 300, 310. 3(3-0) F.* First of two-semester sequence concerned with the physiological foundations of behavior. The emphasis in this first course is basic vertebrate neuroanatomy and neurophysiology. LeVere

PSY 504 Advanced Educational Psychology. *Preq.: Six hrs. of PSY. 3(3-0) F.* A critical appraisal of current psychological findings that are relevant to educational practice and theory. Baker-Ward

PSY 505 History and Systems of Psychology. *Preqs.: PSY 200, 300, 310, 320 or CI or grad. status. 3(3-0) S.* The aim of this course is to acquaint students with the history of psychology and psychological systems and to give students some practice in taking different approaches to a particular problem area. Converse

PSY 510 Learning and Motivation. *Preq.: Grad. standing or PBS status. 3(3-0) S.* A systematic analysis of some of the major classes of variables determining behavioral change. Learning variables analyzed within their primary experimental setting, and emphasis upon the diversity of the functions governing behavior change rather than upon the development of some comprehensive theory. Both learning and motivational variables examined as they contribute to changes in performance within the experimental setting. Cole

PSY 511 Advanced Social Psychology. *Preq.: Grad. standing or PBS status. 3(3-0) F.* A survey of theory and research in social psychology through reading and discussion of primary source materials. In addition, the course deals with issues of methodology, ethical questions in social psychological research and application of research findings to the world at large. Luginbuhl

PSY 512 Action Research in Psychology. *Preq.: ST 507 or equivalent; Coreq.: ST 508 or equivalent. 3(3-0) S.* Action research models in psychology and their relationships to research methods: Research in field settings and implications for ethics and social responsibility, internal and external validity, experimenter and volunteer effects and problems of measurement. Gray

PSY 513 Psychology and Law. *Preq.: Grad. standing. 3(3-0) S. Alt. yrs.* Interaction between psychology and law, including pretrial surveys, jury selection, eyewitness identification, jury decision making, competence to stand trial, insanity, expert testimony, sexual assault and the death penalty. Luginbuhl

PSY 514 Foundations of Behavioral Research. *Preqs.: Grad. standing, ST 507 and PSY 535 or equivalent. 3(3-0) F.* A course in scientific behavioral research, basically psychological in nature, designed to help students understand the fundamental nature of the scientific approach to problem solution. Technical and methodological problems considered. The course emphasizes the controlled and objective study of the relations among phenomena, the scientific approach and the relations between a research problem and the design and methodology of its solution. Westbrook

PSY 520 Cognitive Processes. *Preq.: Grad. standing or PBS status. 3(2-2) F.* This course emphasizes the results from research on a number of complex processes (*e.g.*, remembering, concept learning, problem solving, acquisition and use of language) and the theories that have been proposed to explain these results. Newman

PSY 530 Advanced Abnormal Psychology. *Preqs.: PSY 200, 370. 3(3-0) S.* The causes, symptomatic behavior and treatment of the major personality disturbances. Emphasis on theory, experimental psychopathology and preventive measures. Graduate Staff

PSY 533 Biological Factors in Abnormal Behavior. *Preqs.: Six hrs. of PSY and six hrs. of biology. 3(3-0) Sum. Alt. yrs.* Biological influences and predispositions in abnormal human behavior, including brain damage and disconnection syndromes, psychosomatic illnesses, anxiety and neurosis, manic-depressive disorder, schizophrenia and disorders of memory, eating, movement, sexual behavior and others. Assumes only a moderate biology background. Kalat

PSY 535 Tests and Measurements. *Preq.: Six hrs. of PSY. 3(3-0) F,S.* A study of the principles of psychological testing including norms and units of measurement, elementary statistical concepts, reliability and validity. In addition, some attention devoted to the major types of available tests such as general intellectual development, tests of separate abilities, achievement tests, measures of personality and interest inventories. Westbrook

PSY (IE) 540 Human Factors in Systems Design. *Preq.: IE 452 or PSY 340; Coreq.: ST 507 or 515. 3(3-0) F.* Introduction to problems of the systems development cycle, including human-machine function allocation, military specifications, display-control compatibility, the personnel sub-system concept and maintainability design. Detailed treatment given to people as information processing mechanisms. Pearson

PSY 543 Ergonomic Performance Assessment. *Preqs.: PSY 200, ST 507 and 508 or equivalent. 3(3-0) F. Alt. yrs.* Fundamentals of ergonomic performance measurement used to assess the effects of environment and system design on human performance. Treatment of topics such as workload measurement, measurement of complex performance, simulator studies, measurement of change, task taxonomies, criterion task sets and statistical methods of task analysis. Problems of laboratory and field research, measurement of change and generalizability of findings. Converse

PSY (IE) 545 Human Performance. *Preqs.: Grad. standing; ST 507 or equivalent. S. Alt. yrs.* Fundamentals of human perceptual and motor abilities basic to skilled operator performance. Theoretical models of man as an operator. The human as an information processing mechanism. Motor skills learning, performance decrement and information feedback. Channel capacity, stress, fatigue, arousal theory. Attention, time-sharing and workload. Sustained performance, vigilance, monitoring, search, inspection and tracking. Circadian rhythms; sleep loss; shiftwork. Pearson

PSY 546 Human Information Processing. *Preqs.: PSY 200, ST 507 and 508 or equivalent. 3(3-0) S. Alt. yrs.* Fundamentals of human information processing basic to skilled operator performance and the design of displays, controls and complex systems. Treatment of topics such as channel capacity, working memory, long-term memory, decision making, attention and process monitoring. Problems of display and control design and evaluation, evaluation of textual material, and human-computer interaction. Converse

PSY 560 Personnel Selection Research. *Preqs.: Six hrs. of grad. ST, PSY 535. 3(3-0) F. Alt. yrs.* A survey of theoretical, methodological and research literature on personnel selection. Topics include organization, task and person analyses, validation strategies, utility and equal opportunity issues and selection strategies. Emphasis on research.

Thayer

PSY 561 Training Research. *Preqs.: Six hrs. of grad. PSY and six hrs. of grad. ST. 3(3-0) F. Alt. yrs.* A survey of conceptual and research literature on training. Topics include needs assessments, learning, transfer, maintenance, criterial and evaluation issues, as well as a review of research on specific training techniques. Emphasis on research methods and findings, not skill development in specific training techniques.

Thayer

PSY 565 Organizational Psychology. *Preq.: Nine hrs. of PSY. 3(3-0) F.* A study of the application of behavioral science, particularly psychology and social psychology, to organizational and management problems.

Pond

PSY 566 Organization Development and Change. *Preq.: PSY 565. 3(3-0) S.* A survey of theory and research in organization development. Attention directed to: (1) methods of diagnosing the need for organizational change, (2) techniques currently used to implement and evaluate organizational change, (3) professional ethics and other issues dealing with the client-consultant relationship. Emphasis on developmental approaches originating from psychology and allied fields.

Pond

PSY 570 Theories of Personality. *Preq.: Grad. standing. 3(3-0) F.* A review of theories of personality, with emphasis on research, application in psychotherapy and measurement, principles involved in similarities and differences among them and development of a personal model.

Horan

PSY 571 Individual Intelligence Measurement. *Preq.: PSY 535 and consent of school psychology coordinator. 3(3-0) S.* A practicum in individual intelligence testing with emphasis on the Wechsler Bellevue, Stanford-Binet, report writing and case studies.

Walker

PSY 572 Psychological Survey Operations. *Preq.: ST 507 or equivalent; Coreq.: ST 508 or equivalent. 3(3-0) S.* Emphasis on application of survey operational methods to problems of interest to psychologists in governmental, institutional and industrial settings. Course designed to provide competency in questionnaire construction, data collection, design and analysis procedures and report writing. The class will design, conduct and analyze a survey on topic of their own selection in the area of psychology.

Klein

PSY 573 Theories of Intelligence. *Preq.: Grad. standing. 3(3-0) S. Alt. yrs.* Critical analysis of the psychological construct of intelligence. Traditional theories, as well as cognitive developmental, information-processing, comparative psychology, artificial intelligence, cross-cultural and epistemological approaches to intelligence explored.

Horan

PSY 576 Advanced Developmental Psychology. *Preq.: Nine hrs. of PSY, including PSY 376, PSY 475 or PSY 476. 3(3-0) F.* A survey of the role of growth and development in human behavior, particularly during the child and adolescent periods. This course pays particular attention to basic principles and theories in the area of developmental psychology.

Snyder

PSY 577 Adolescent Development. *Preq.: 6 hours in PSY or CI. 3(3-0) S, Sum. Alt. yrs.* Current theories and research on development during adolescence. Topics include: physical growth, cognitive changes, relationships with peers, parents and teachers, quest for identity and independence, morality and sexuality.

Snyder

PSY 579 Adult Development and Aging. *Preq.: PSY 576 or equivalent. 3(3-0) S. Alt. yrs.* Critical examination of theory and research associated with the study of normal adult development and aging. Topics include: methodological issues; cognitive and intellectual

development; changes in learning and memory; personality and emotional development; socialization processes; psychophysiological and biological factors. Hess

PSY 580 Psychological Consultation. *Preq.: Nine hrs. grad. PSY or ED. 3(2-2) S.* Introduction to psychological consultation with emphasis on school setting. Presentation of various consultation models and theoretical bases. Development of skills in practice of consultation. Erchul

PSY 585 Advanced Problems in Psychology. *Preq.: Grad. standing. 1-3 F,S.* Offers opportunities to explore various areas of psychology. Sections: Section D, applied developmental psychology; Section X, experimental psychology; Section I, industrial-organizational and vocational psychology; Section S, social psychology. Graduate Staff

PSY 591 Special Topics in Psychology. *Preq.: 6 hrs. of PSY; Coreq.: 3 hrs. of ST. 1-3 F,S.* Course provides opportunity for exploration in depth of advanced areas and topics of current interest. Graduate Staff

PSY (IE) 593 Area Seminar in Ergonomics. *Preq.: Grad. standing or PBS status. 1(0-2), Max. 3. F.* Introduction to ergonomics as an area of study; historical aspects; contemporary issues; ethical questions; overview of campus research, facilities and courses in the area; consideration of information sources, financial support for research proposals and employment opportunities. Graduate Staff

PSY 594 Area Seminar in Human Resources Development. *Preq.: CI. 1-3, Max. 6. F,S.* The following topics dealt with: (1) human resources development as an area of inquiry, (2) methods of inquiry, (3) contemporary issues, (4) ethical questions, (5) relationship to other areas within psychology. Drewes

PSY 595 Area Seminar in School Psychology. *Preq.: Grad. standing or PBS status. 1-3, Max. 6. F,S.* The following topics dealt with: (1) the development of school psychology as a professional area, (2) methods of inquiry, (3) scientific and theoretical bases, (4) contemporary issues, (5) ethical questions, (6) relationship to other areas within psychology. Graduate Staff

PSY 599 Research Problems in Psychology. *Preq.: CI. Credits Arranged. F,S.* Research project for graduate students supervised by members of the graduate faculty. Research to be elected on basis of interest of student and not to be part of thesis or dissertation research. Graduate Staff

FOR GRADUATES ONLY

PSY 600 Advanced Problems in Perception. *Preq.: PSY 500. 3(2-2) S. Alt. yrs.* An exploration of advanced topics in the field of perception. Specific coverage varies from year to year but may include examination of sensory/perceptual processes in audition and other non-visual systems; attentional and organizational factors in perception, information processing approaches to perception, theories of perception and/or perceptual/motor skills. Mershon

PSY 602 Physiological Psychology. *Preq.: PSY 502 and/or CI. 3(3-0) S.* PSY 602, the sequel to PSY 502, concentrates on relating the neuroanatomy and neurophysiology studied in PSY 502 to overt observable behaviors such as sleep-waking, motivation-emotion and reflexive and learned behaviors. LeVere

PSY 611 Social Psychology: Small Groups Research. *Preq.: PSY 511. 3(3-0) S.* Surveys the literature and research pertaining to social psychological processes in and between groups. Course content includes basic principles of group formation, role differentiation, communication, influence, norms, social exchange, equity, cooperation/conflict, decision making and pro-social behavior. Environmental factors affecting group behavior also considered. In conjunction with each substantive topic, the suitable methodologies for research considered. Smith

PSY 612 Attitudes. *Preq.: Six hrs. grad. PSY or CI. 3(3-0) F.* Theory and research in attitude formation and change; analysis of various persuasion paradigms employed in mass communication and group influence processes; study of individual attitudinal structures, resistance to persuasion, behavior as a precursor to attitude change; attitude behavior discrepancy, attitude measurement techniques and methodological considerations. Klein

PSY 613 Attribution. *Preq.: PSY 511. 3(3-0) S. Alt. yrs.* The determinants and consequences of assigning causes for the behavior of others and ourselves. Topics include attributional models, emotional states, success and failure, responsibility assignments, self-handicapping, self-fulfilling prophecy, motivational biases and applications to therapy. Lugimbuhl

PSY 614 Stress and Coping. *Preq.: Two grad. PSY courses. 3(3-0) F. Alt. yrs.* Discussion of current research findings and theories in area of psychosocial stress. Topics include: biology of the stress response, methodology, physical, behavioral and psychological reactions to stress, and relationships between personality and social support to the development of stress-related disorders. Klein

PSY 620 Advanced Problems in Cognition. *Preq.: PSY 520 or CI. 3(3-0) S.* This seminar provides the opportunity for exploring in depth problems and issues in memory, concept learning, problem solving, psycholinguistics and other areas in cognition. Newman

PSY 635 Psychological Measurement. *Preqs.: ST 507, 511 or equivalent, 12 hrs. of PSY. 3(3-0) F.* Theory of psychological measurement. Statistical problems and techniques in test construction. Cunningham

PSY (IE) 640 Skilled Operator Performance. *Preqs.: PSY 545, ST 507 or ST 515. 3(3-0) F. Alt. yrs.* Theories of the human operator considered with regard to the classical problems of monitoring, vigilance and tracking. Factors such as biological rhythm, sleep loss, sensory restriction, environmental stress and timesharing considered as they interact with and determine overall systems efficiency. Pearson

PSY 650 Vocational Psychology. *Preqs.: ST 507, PSY 514, 635 or equivalent. 3(3-0) F. Alt. yrs.* The study of the individual's vocational behavior and development through the years of choice and adjustment. An up-to-date review and synthesis of research and theory in the field of vocational psychology. Empirical studies and theoretical statements in the field appraised and evaluated to determine what behavioral laws apply to vocational phenomena. Westbrook

PSY 665 Work Motivation. *Preq.: PSY 565. 3(3-0) S. Alt. yrs.* Theory and research in work motivation. An in-depth examination of motivation theory as it pertains to the study of individual behavior in work settings. Pond

PSY 671 Psychology of Families and Parenting. *Preq.: Nine hrs. grad. PSY or ED. 3(3-0) F. Alt. yrs.* Special topics in the area, including family influences on cognitive development, effects of parental divorce on children, single-parenting, step-families, child abuse and ethnic/cultural differences in family functioning. A critical examination of traditional and contemporary parenting approaches and an introduction to family therapy. Erchul

PSY 672 Personality Measurement. *Preqs.: PSY 570, 571. 3(2-3) S.* Theory and practicum in individual personality testing of children and adults with emphasis on projective techniques, other personality measures, report writing and case studies. Walker

PSY 674 Psychological Intervention I. *Preqs.: PSY 672, 530 and CI. 3(2-2) F.* This course designed to examine theories, research, techniques, ethics and professional responsibilities related to approaches to psychological intervention. Types of psychological intervention to be studied include behavior modification, milieu approaches, crisis intervention techniques and group process methods, in addition to more intensive relationship

approaches. A close integration of experiences, content and supervision emphasized in a variety of professional settings with a wide range of personal problems and age groups.

Graduate Staff

PSY 675 Psychological Intervention II. *Preq.: PSY 674. 3(2-2) S.* The primary purpose of this course is to provide students opportunities to acquire information, conceptual frameworks, interpersonal skills and a sense of ethical responsibility, all basic to their further development as practicing psychologists. A major effort in the course made to help the student increase his/her interpersonal skills as a means of promoting the psychological growth and effectiveness of others.

Graduate Staff

PSY 676 Cognitive Development. *Preq.: PSY 576. 3(3-0) S. Alt. yrs.* Examination of research and theory in cognitive development. The primary focus on childhood, but implications for the entire lifespan addressed. Application of cognitive developmental principles in creating interventions and educational programs also discussed.

Hess

PSY 677 Social Development. *Preq.: PSY 576. 3(3-0) Alt. yrs.* Survey of current theory and research on the development of social behavior systems, including attachment, aggression, gender-role behavior, prosocial behavior. Attention to the role of social class, race and culture, and to contemporary phenomena such as day care, single-parent and dual-career families, child abuse.

Graduate Staff

PSY 680 Systems Theory and Applications in Human Resource Development. *Preq.: PSY 594 or equivalent. 3(3-0) F.* An introduction to the systems approach and general systems theory. (1) Concepts and terminology of general systems theory, (2) techniques currently used to access system requirements and (3) methods of analyzing system performance. Emphasis on application of systems techniques to the design and implementation of human resource development programs.

Drewes

PSY 681 Quasi-experimental Evaluation Design. *Preq.: ST 507 or equivalent. 3(3-0) S.* An introduction to quasi-experimental design as applied to HRD program evaluation: (1) Methods of assessing informational needs, (2) recognition of internal and external validity threats, (3) design of quasi-experiments to minimize threats and (4) use of results by program decision makers.

Drewes

PSY 691 Special Topics in Psychology. *Preqs.: Grad. standing, CI. 1-3 F,S.* Course provides opportunity for exploration in depth of advanced topical areas which, because of their degree of specialization, not generally involved in other courses; for example, multivariate methodology in psychology, computer simulation, mathematical model building. Some new 600-level courses will first be offered under this title during the developmental phase and as such may involve lectures and/or laboratories.

Graduate Staff

PSY 693 Psychological Clinic Practicum. *Preqs.: Twelve hrs. in grad. PSY, which must include clinical skill courses PSY 571 and PSY 672 and/or CI. Max. 12 F,S.* Clinical participation in interviewing, counseling, psychotherapy and administration of psychological tests. Practicum to be concerned with adults and children.

Erchul, Horan, Walker

PSY 697 Advanced Seminar in Research Design. *Preqs.: Nine hrs. of statistical methods and research or CI, advanced grad. status. 3(3-0) F.* A seminar-type course with topics selected each semester in accordance with the interests and needs of the students. Attention given to the research strategies that underlie educational and psychological research, to the development of theoretical constructs, to a critical review of research related to problems in which the students interested, and to a systematic analysis and critique of research problems in which the students engaged.

Graduate Staff

PSY 698 Internship in Psychology. *Preqs.: Master's degree in PSY and approval of advisory committee. 1-12 F,S.* Supervised work experience in an appropriate setting with professional supervision in the field from a doctoral level psychologist with credentials

and/or experience in the appropriate specialty in psychology. Experience consists of full time for one semester or half time for an academic year or equivalent time.

Erchul, Horan, Walker

PSY 699 Thesis and Dissertation Research. *Preqs.: Grad. standing, CI. Credits arranged. F,S.* Individual research on a thesis or dissertation problem; a maximum of six credits allowed toward the master's degree, but any number toward the Ph.D. degree.

Graduate Staff

Recreation Resources Administration

GRADUATE FACULTY

Professor P. S. Rea, Head

Associate Professor B. E. Wilson, Graduate Administrator

Professors: H. A. Devine, A. Lumpkin, C. D. Siderelis, R. E. Sternloff, M. R. Warren; Professors Emeriti: T. I. Hines, W. E. Smith; Associate Professors: S. L. Kirsch, R. R. Perdue; Adjunct Associate Professor: H. K. Cordell; Associate Professors Emeriti: G. A. Hammon, L. L. Miller; Assistant Professor: C. S. Love

The Department of Recreation Resources Administration offers programs of study leading to the Master of Science and Master of Recreation Resources Administration degrees. The programs are based on an interdisciplinary approach and are designed to meet the problems and opportunities posed by changing social forces which affect the recreation, park and leisure professions. Students pursuing these degrees have an opportunity to develop an understanding of the relationship between recreation and disciplines such as forestry, wildlife management, horticulture, landscape design, conservation, economics and business, politics, sociology and anthropology.

The Master of Science degree is designed for students who are interested in the advanced applications of research to the management and operations of recreation and park agencies. Students are required to complete a minimum of 30 hours of graduate work. The program consists of a major and minor field of study. The minor may be concentrated wholly in a different discipline or may consist of courses selected from the offerings of two departments.

Each candidate for the Master of Science degree is required to complete a thesis representing an original investigation as a part of the minimum requirements for the degree.

The Master of Recreation Resources Administration degree is designed for students who are interested in the applications of advanced management and organization principles in the operation of recreation, park and leisure service agencies. Requirements for the Master of Recreation Resources Administration degree include a minimum of 36 hours of course work. In lieu of a thesis the student will be required to complete additional departmental course work and an independent master's project.

SELECTED ADVANCED UNDERGRADUATE COURSES

RRA 420 Resort Management and Operations. *Preq.: RRA 152. 3(3-0) S.*

RRA 438 Recreation for Special Populations. *Preq.: RRA 358. 3(3-0) F.*

RRA 442 Recreation and Park Interpretive Services. *Preq.: Jr. standing. 3(2-3) F,S.*

RRA 443 Applied Recreation and Park Interpretive Services. *Preqs.: RRA 442, jr. standing. 3(1-6) S.*

RRA 451 Principles of Recreation Planning and Facilities Development. *Preq.: RRA 358. 3(2-3) F,S.*

RRA 453 Administrative Policies and Procedures. *Preq.: RRA 359. 3(3-0) F.*

RRA 454 Recreation and Park Finance. *Preqs.: Six hours of RRA courses and sr. standing. 3(3-0) S.*

RRA 480 Recreation Analysis and Evaluation. *Preqs.: RRA 359, ST 311. 3(2-2) S.*

FOR GRADUATES AND ADVANCED UNDERGRADUATES

RRA 500 Theories of Leisure and Recreation. *3(3-0) F.* Analysis of leisure and recreation and a study of their origin and development as revealed by man's behavioral patterns. Interpretation of the influence and social significance of leisure and recreation concepts on contemporary American culture and their implications on future recreation thought and action.
Warren

RRA 501 Research Methods in Recreation. *Preqs.: ST 311. 3(3-0) F.* Examination and understanding of advanced scientific investigative methods in their application toward explaining recreation and leisure behavioral phenomena and for the resolution of recreation management problems.
Perdue

RRA (EB) 503 Economics of Recreation. *Preq.: EB 301 or 401. 3(3-0) F.* The principal emphasis on identity and importance of economic information for planning. The market mechanism and government examined as they affect and interact to affect allocation of resources to recreation, distribution of recreation services and behavior of recreationists. Other topics include demand analysis, economics of planning, cost/benefit analysis, secondary economic impacts, public decision making, externalities, public finance and supply considerations in urban and rural recreation situations.
Devine

RRA 504 Recreation and Park Data Systems. *Preqs.: CSC 200, ST 311. 3(3-0) S.* This course includes the analysis of such topics as the identification of maintenance, operation and service delivery work areas in recreation and park agencies for system applications; development of reporting structures; recreation and maintenance activity scheduling; system monitoring; system implementation evaluation.
Siderelis

RRA 505 Quantitative Techniques for Recreation and Natural Resource Management. *Preqs.: CSC 200, ST 311. 3(3-0) S.* A review of the application of specific management science techniques to recreation and natural resource management. Gravity, optimization, simulation and other modeling procedures discussed through a case study approach. The primary emphasis of the course on exposure to techniques and problem formulation rather than development of theoretical bases or computational methodologies.
Devine

RRA 510 Theories of Sport and Fitness Program Management. *Preq.: RRA 358. 3(3-0) F.* The development of a theoretical basis for sport and physical fitness program management. The sociological, psychological, political and economic considerations of sport and fitness studied. Values and motivation of sport and fitness stressed.
Love

RRA 511 Foundations for Sport, Exercise and Fitness Program Management. *Req.: RRA 358. 3(3-0) Every third sem.* The development of a scientific basis for sport, exercise and fitness program development. Characteristics of human growth, development and aging studied as they relate to participation in physical activity. Emphasis on physical fitness evaluation and program development. Rea

RRA 512 Recreational Sports Management. *Req.: RRA 358. 3(3-0) Every third sem.* An overview and analysis of key managerial concerns of the sports enterprise. Problems and issues unique to the sports-oriented service or business stressed. Emphasis on recreational sports settings. Graduate Staff

RRA 520 Concepts of Travel and Tourism. *Req.: Grad. standing. 3(3-0) S.* Theory and research in travel and tourism, including conceptual foundations, research problems and methods and the application of research results to strategic tourism development and marketing. Perdue

RRA (LAR) 562 Computer Cartography. *Req.: Grad. standing or CI. 3(3-0) S.* An introduction to the application of computers and associated analytic technology to problems in natural resource planning and management. The course emphasizes the use of automated mapping and display procedures in land use decision making and involves the student in first-hand experiences with a number of different procedures and computer hardware configurations. Not a general course in computer graphics and deals exclusively with natural resource management applications. Devine

RRA 580 Current Issues in Recreation Resources. *Reqs.: Grad. standing, CI. 1-3 S.* An examination of current issues in recreation resources. Course content varies as changing conditions require new approaches to emerging problems. Graduate Staff

RRA 591 Recreation Resources Problems. *Req.: Advanced undergrad. or grad. status. 1-4 F,S.* Assigned or selected problems in the field of recreation administration, planning, supervision, maintenance, operations, financing or program. Special research problems selected on basis of interest of students and supervised by members of the graduate faculty. Graduate Staff

RRA 595 Special Topics in Recreation Resources. *Reqs.: Grad. standing, CI. 1-3 F,S.* Special topics in various aspects of recreation resources developed under direction of a graduate faculty member on a tutorial basis. Subjects offered under this course listing also used to test and develop new courses. Graduate Staff

FOR GRADUATES ONLY

RRA 675 Field Studies in Recreation. *Req.: Minimum of nine hrs. of grad. credit. 1-4 F,S,Sum.* Experience in applying analytical methods to administrative, managerial and planning problems in providing recreation and park opportunities. Completion of an evaluation project or analytical study for the practicum agency required. Graduate Staff

RRA 690 Recreation Management Seminar I. *Reqs.: RRA 500, 501. 2(0-4) F.* Research and theories of (1) marketing, (2) case law and liability and (3) personnel practices as they relate to the management of recreation resources. Graduate Staff

RRA 691 Recreation Management Seminar II. *Reqs.: RRA 500, RRA 501. 2(0-4) S.* Research and theories of (1) planning and development, (2) financing and (3) maintenance management of recreation resources. Graduate Staff

RRA 692 Advanced Problems in Recreation. *Req.: Twelve hrs. of RRA courses. Credits Arranged. F,S.* Directed research in a specialized phase of recreation other than a thesis problem. Graduate Staff

RRA 696 Seminar in Recreation Research. *Preq. or coreq.: RRA 501. 1(2-0) S.* Research studies, scientific articles and progress reports on research effects presented and critically evaluated. Each student pursuing a graduate degree expected to take this offering twice for one hour of credit each time. **Graduate Staff**

RRA 699 Research in Recreation. *Preq.: Twelve hrs. of RRA courses. Credits Arranged.* F.S. Original research preliminary to writing a master's thesis. **Graduate Staff**

Sociology, Anthropology and Social Work

GRADUATE FACULTY

Professor L. B. Otto, Head

Associate Professor M. P. Atkinson, Associate Head, HASS Programs

Professor W. B. Clifford II, Associate Head, ALS Programs

Professor E. M. Suval, Graduate Administrator

Professors: L. R. Della Fave, V. A. Hiday, C. P. Marsh, R. L. Moxley, P. N. Reid, O. Uzzell, R. C. Wimberley; *Professors Emeriti:* L. A. Drabick, H. D. Rawls, M. E. Voland, J. N. Young; *Associate Professors:* R. C. Brisson, A. C. Davis, S. K. Garber, G. D. Hill, J. C. Leiter, S. C. Lilley, G. S. Nickerson, W. C. Peebles-Wilkins, M. D. Schulman, M. S. Thompson, R. J. Thomson, D. Tomaskovic-Devey, K. M. Troost, M. L. Walek, J. M. Wallace, E. M. Woodrum, M. T. Zingraff; *Associate Professor Emeritus:* J. G. Peck; *Assistant Professors:* R. S. Ellovich, T. J. Hoban, T. M. Hyman, B. J. Risan, M. L. Schwalbe; *Assistant Professor Emeritus:* C. C. Dawson

ASSOCIATE MEMBERS OF THE DEPARTMENT

Professors: V. E. Hamilton, T. N. Hobgood Jr., R. D. Mustian, M. M. Sawhney

The Department of Sociology and Anthropology offers programs of study in sociology leading to the advanced degrees of Master of Sociology, Master of Science and Doctor of Philosophy. The core program includes sociological theory, research methods and quantitative analysis. Major substantive areas of specialization include agriculture and rural sociology, family, crime and deviance, social psychology, development, change and comparative sociology, social demography and ecology, community, inequality, and work, industry and organization.

The Master of Science and Doctor of Philosophy degrees are oriented toward the basic and applied science of sociology. Special attention is given to sociological skills for analyzing social factors and policies affecting informal groups, formal organizations, families, communities, regions, nations and international development. The Master of Sociology is designed for applied sociology careers in local, state and federal agencies; management and administration; human service delivery; program development and evaluation; and the teaching of sociology in secondary schools. The program focuses on the application of sociological

theory, methods and research to social issues and problems. A practicum gives the student experience in an agency/organization.

The department also offers a minor in cultural anthropology at the Master's level. Graduate courses are designed to give a broad background in major concepts of cultural anthropology with emphasis on theory. These offerings may be supplemented with courses at the 400 level.

Computer facilities are available to graduate students and faculty in the department as described under "Academic Computing Facilities." Graduate students on assistantships and fellowships are normally provided office facilities. Research opportunities reflect the wide range of interests of the graduate faculty and the imagination of the students themselves. The department also has a statewide extension focus in applied sociology.

SELECTED ADVANCED UNDERGRADUATE COURSES

- ANT 416 Research Methods in Cultural Anthropology.** *Preq.: Six hrs. ANT. 3(3-0).*
- ANT 420 Biological Bases for Human Social Behavior.** *Preq.: ANT 251, or BS 100 or 105, GN 301, or equivalent. 3(3-0).*
- ANT 498 Special Topics in Anthropology.** *Preq.: Six hrs. of SOC/ANT. 1-6.*
- SOC 400 Theories of Social Structure.** *Preq.: 3 credits of SOC, 200 level. 3(3-0).*
- SOC 401 Theories of Social Interaction.** *Preq.: 3 credits of SOC, 200 level. 3(3-0).*
- SOC 402 Urban Sociology.** *Preq.: SOC 202. 3(3-0).*
- SOC 410 Sociology of Organizations.** *Preq.: SOC 202. 3(3-0).*
- SOC 414 Social Class.** *Preq.: SOC 202. 3(3-0).*
- SOC 418 Sociology of Education.** *Preq.: SOC 202. 3(3-0).*
- SOC 420 Sociology of Corrections.** *Presq.: SOC 306 and PS 311. 3(3-0).*
- SOC 425 Juvenile Delinquency.** *Preq.: SOC 202, SOC 301 desirable. 3(3-0).*
- SOC 426 The Juvenile Justice System.** *Preq.: SOC 202. 3(3-0).*
- SOC 440 Social Change.** *Preq.: SOC 202. 3(3-0).*
- SOC 490 Senior Seminar in Sociology.** *Presq.: Sr. standing and consent of department. 3(3-0).*
- SOC 498 Special Topics in Sociology.** *Preq.: Six hours SOC above 200 level. 1-6.*

FOR GRADUATES AND ADVANCED UNDERGRADUATES

ANT 508 Culture and Personality. *Preq.: ANT 252 or 6 hrs. in Cultural Anthropology. 3(3-0).* The course focuses on the interplay between cultural norms and the enculturation process. From a cross-cultural perspective, it examines the process by which cultural norms transmitted and learned, as well as the effect of culture change on the individual. The historical development of the field as well as contemporary trends also discussed in both theoretical and applied contexts.

Graduate Staff

ANT 511 Anthropological Theory. *Preqs.: ANT 252 or 6 hrs. in Cultural Anthropology. 3(3-0).* Approaches theory from both an historical and contemporary point of view. Emphasizes the key anthropological concept of culture and its significance for understanding man and his works. Graduate Staff

ANT 512 Applied Anthropology. *Preq.: ANT 252 or CI. 3(3-0).* Includes a review of the historical development of applied anthropology and a study of anthropology as applied in government, industry, community development, education and medicine. The processes of cultural change analyzed in terms of the application of anthropological techniques to programs of developmental change. Graduate Staff

ANT 591 Special Topics in Anthropology. *Preq.: ANT 501 or equivalent. 1-6.* This course designed to provide the opportunity for students to investigate in depth some particular topic in anthropology. Course content and mode of study vary, reflecting current student needs and interests. Topics determined by the faculty member(s) and student. Graduate Staff

SOC 501 Leadership. *Preq.: SOC 202 or equivalent. 3(3-0).* Leadership in various fields of American life; analysis of factors associated with it; techniques of leadership. Stresses recreational, scientific and executive leadership procedures. Graduate Staff

SOC 502 Society, Culture and Personality. *Preq.: SOC 202 or equivalent. 3(3-0).* Studies human personality from its origins in primary groups through its development in secondary contacts and its ultimate integration with social norms. Explores comparative anthropological materials but places emphasis on the normal personality and individual adjustment to our society and culture. Dynamics of personality and character structure analyzed in terms of society's general culture patterns and social institutions. Graduate Staff

SOC 505 Medical Sociology. *Preq.: Six credits in SOC or grad. standing or PBS status. 3(3-0).* Advanced sociological analysis of health care organizations and their systemic linkage to other community institutions. Measurement of health and illness and their social significance. Applications of sociological and social-psychological theories to practitioner-client relationships and interaction. Implications of alternative models of health care provision. Graduate Staff

SOC 508 Social Organization. *Preq.: SOC 400 or SOC 511. 3(3-0).* Introduction to the study of social structure. Focus on inequality, work, organizations, the economy, the state. Classic writings and their impacts. Graduate Staff

SOC 509 Population Problems. *Preq.: SOC 202 or equivalent. 3(3-0).* Examines population growth, rates of change and distribution. Emphasizes functional roles of population, i.e., age, sex, race, residence, occupation, marital status and education. Population dynamics stressed: fertility, mortality and migration. Population policy analyzed in relation to national and international goals stressing a world view. Graduate Staff

SOC 510 Industrial Sociology. *Preq.: SOC 202 or equivalent. 3(3-0).* Industrial relations analyzed as group behavior with a complex and dynamic network of rights, obligations, sentiments and rules. This social system viewed as an interdependent part of total community life. The background and functioning of industrialism studied as social and cultural phenomena and its social problems analyzed. Graduate Staff

SOC 511 Sociological Theory. *Preqs.: Six hrs. SOC and grad. standing or PBS status. 3(3-0).* The interdependence of theory and method; the major theoretical and methodological systems. Examines selected cases of research in which theory and method classically combined. Graduate Staff

SOC 512 Survey of Family Sociology. *Preq.: SOC 202. 3(3-0).* Examines structural and demographic continuities and changes for American families in general and within major

subgroups (e.g., race, ethnicity, social class). Historical and cross-cultural comparisons considered. Assesses the impact of families upon their members and the dynamics of marital and family relationships. Graduate Staff

SOC 513 Community Organization and Development. *Preq.: SOC 202 or equivalent. 3(3-0).* Community organization viewed as a process of bringing about desirable changes in community life. Community needs and resources studied. Democratic processes in community action and principles of organization stressed, along with techniques and procedures. Roles of lay and professional workers analyzed. Graduate Staff

SOC 514 Developing Societies. *Preq.: Six hrs. SOC or ANT or grad. standing or PBS status. 3(3-0).* Defines major problems posed for development sociology and explores the social barriers and theoretical solutions for development set forth with regard to the newly-developing countries. Significant past strategies reviewed and main themes in current development schemes presented. Untested strategies for the future proposed and discussed. These problems examined in their national and international contexts. Graduate Staff

SOC 515 Deviant Behavior. *Preq.: Six hrs. SOC or ANT or grad. standing or PBS status. 3(3-0).* Topics include: the inevitability of deviance and its social utility; cross-cultural variations in appearance and behavioral cues for labeling the deviant; descriptive and explanatory approaches to kinds and amounts of deviance in contemporary American society; social change, anomie and social disorganization theories; the process of stigmatization; formal and informal societal responses to deviance and the deviant; social action implications. Graduate Staff

SOC 516 Social Control. *Preq.: Six hrs. SOC above 200 level or grad. standing or PBS status. 3(3-0).* The need, functions, utilization and effects of both informal and formal social control mechanisms examined. Theoretical perspectives on social control and the empirical support for these positions emphasized and critically evaluated. Graduate Staff

SOC 520 Sociology of Religion. *Preq.: SOC 202 or equivalent or grad. standing or PBS status. 3(3-0).* Alternative theoretical analyses presented for religious beliefs, practices and organizations and the relationships between these and other social phenomena. The utility and deficiencies of each conceptual framework assessed through general applications and case studies. Major research findings in this classical field of sociology reviewed. Contemporary trends and issues concerning religion in society addressed. Graduate Staff

SOC 523 Sociological Analysis of Agricultural Development. *Preq.: Six hrs. SOC or grad. standing. 3(3-0).* Systematic sociological analysis of agricultural development and change, emphasizing less-developed countries. Review of classical and contemporary theoretical perspectives. Specific topics: land tenure and agricultural development; peasants and peasant societies; peasant revolt and revolution; women and development. Graduate Staff

SOC 534 Sociology of U.S. Agriculture. *Preqs.: Six hrs. of SOC or grad. standing. 3(3-0).* Analysis of the structural transformation of U. S. agriculture in the 19th and 20th centuries, particularly in terms of the role of the state in agricultural development. Review of theoretical perspectives and research in rural sociology and the sociology of agriculture. Graduate Staff

SOC 541 Social Systems and Planned Change. *Preq.: Three hrs. SOC. 3(3-0).* An examination of social systems within the framework of both functional theory and conflict theory, with particular emphasis upon system change and the planning of social change. Graduate Staff

SOC 555 Social Stratification. *Preq.: Six hrs. SOC. 3(3-0).* The theoretical background, methodological approaches and analysis of the consequences of systems of stratification. Emphasizes the static and dynamic qualities of stratification systems on relations within and between societies. Attention to the integrative and divisive quality of stratification as expressed in life styles, world views, etc. Graduate Staff

SOC (EB) 574 The Economics of Population. *3(3-0).* (See economics and business.)

SOC 590 Applied Research. *Preq.: SOC 202 or equivalent. 3(3-0).* Studies research process with emphasis upon its application to action problems. The development of research design to meet action research needs stressed. Graduate Staff

SOC 591 Special Topics in Sociology. *Preq.: CI. 1-6.* An examination of current problems organized on a lecture-discussion basis. Course content varies as changing conditions require new approaches to emerging problems. Graduate Staff

SOC 595 Practicum in Sociology. *Preqs.: Grad. standing in the Master of Sociology program and 9 hrs. of SOC at the 500-600 level. 3-6.* Opportunity for student under the supervision of graduate advisory committee chairman and organization/agency supervisor to develop and demonstrate competency in the area of graduate specialization through application of sociological knowledge to practical problems facing the organization/agency. Graduate Staff

FOR GRADUATES ONLY

SOC 601 Urban Ecology. *Preq.: SOC 509 or equivalent. 3(3-0).* The course involves an historical approach to the development of the field as well as an analysis of the present state of the field. Because of the range of subject matter subsumed under the topic of ecology, the linkages between sociology and other disciplines concerning themselves with the subject delineated and examined. Graduate Staff

SOC 610 Formal Organizations. *Preq.: SOC 511 or equivalent or another course on organizations or CI. 3(3-0).* Sociological study of bureaucracies and other formal organizations, including theoretical roots, current theory and research, especially on organization-environment relations. Sociological assessment of psychological, economic and managerial theories of organizations. Graduate Staff

SOC 611 Research Methods in Sociology I. *Preqs.: SOC 300, ST 311 or equivalent. 3(3-0).* Issues in philosophy of science, causation, relationship of theory and research. Qualitative, experimental and survey design methodologies. Graduate Staff

SOC 612 Scaling and Indexing for Social and Behavioral Data. *Preqs.: ST 311, SOC 416 or equivalent. 3(3-0).* A basic introduction to the theory of measurement and scaling and to types of simple and composite measures used in the social and behavioral sciences. The development and utility of simple and composite indexes, paired comparison, equal appearing interval, summated rating cumulative, factor, latent structure and self-anchoring scales examined by means of problems and examples. Graduate Staff

SOC 615 Research on Crime and Deviance. *Preq.: SOC 515 or equivalent. 3(3-0).* Major topics include: an examination of conceptual problems and research issues and methods in the study of crime and deviance; an assessment of current research on crime causation and deviance processes; an examination of research on social control processes and agencies; and an assessment of social action and evaluative research. A variety of substantive topics dealt with in the context of the above topical areas including: delinquency, drug usage, mental illness, obesity, stuttering, suicide, prostitution, homicide and rape. Graduate Staff

SOC 616 Crime and Collective Action. *Preq.: SOC 515 or equivalent. 3(3-0).* Examines organized and spontaneous community responses to criminality, other normative violations and unpopular governments. Compares and critiques alternative theoretical explanations for the emergence of legal and extralegal punishment. Applies sociological interpretations to contemporary community and societal policy including economic, political and social consequences of crime. Graduate Staff

SOC 621 Social Psychology. *Preq.: Six hrs. SOC. 3(3-0).* The objective of this course is to present the major ideas of social psychology in the context of the theoretical orientations from which they have emerged. The nature and role of theory in social psychology exam-

ined. The social psychologies of various theorists then examined in terms of their particular approaches including the Gestalt, Field, Role, Psychoanalytic and Reinforcement orientations and combinations of these. Graduate Staff

SOC 628 Sociology of Gender. *Preq.: SOC 512 or CI. 3(3-0).* Reviews micro- and macro-level theories which explain the development and patterns of gendered behavior. Emphasis is on understanding gender as a variable in research. Focus on both how gender roles have developed and how individuals come to exhibit gender-typed behavior. Graduate Staff

SOC 631 Population Analysis. *Preq.: SOC 509 or equivalent. 3(3-0).* Methods of describing, analyzing and presenting data on human populations; distribution, characteristics, natural increase, migration and trends in relation to resources. Graduate Staff

SOC 632 Contemporary Family Theory and Research. *Preq.: SOC 512 or CI. 3(3-0).* Emphasis on contemporary research, theory and methodological techniques used by sociologists who study families. Critical examination of where the field is now and where it appears to be heading. Primarily for graduate students designing or doing research about families. Graduate Staff

SOC 633 The Community. *Preq.: Six hrs. SOC. 3(3-0).* The community viewed in sociological perspective as a functioning entity. A method of analysis presented and applied to eight "dimensions," with emphasis on the unique types of understanding to be derived from measuring each dimension. Finally, the effect of change on community integration and development analyzed. Graduate Staff

SOC 641 Statistics in Sociology. *Preq.: ST 507 or equivalent. 3(3-0).* The application of statistical methods of sociological research. Emphasis on selecting appropriate models, instruments and techniques for the more frequently encountered problems and forms of data. Graduate Staff

SOC 645 Advanced Sociological Measurement. *Preqs.: SOC 611; ST 507 or equivalent. 3(3-0).* Various issues concerning the measurement of social variables examined and techniques described. These issues and techniques include operationalism and epistemic correlation, levels of measurement, transformations, social indicators, scaling, dimensionality, validity and reliability. Existing examples and potential applications in sociological research considered. Graduate Staff

SOC 646 Advanced Sociological Analysis. *Preqs.: SOC 611; ST 507 or equivalent. 3(3-0).* Advanced analysis techniques adaptable to the needs of sociological research examined. Special attention given to causal analysis, the analysis of change, and aggregate *versus* individual level data analyses. Sociological examples considered. Emerging issues and techniques given attention. Graduate Staff

SOC 650 Contemporary Sociological Theory. *Preq.: SOC 511 or equivalent. 3(3-0).* Works by major figures who represent leading schools of sociological theory in the post-World War II period are studied as primary sources. Underlying assumptions are made explicit, the structure of the theory, including propositions, are examined critically, and relationships with other theoretical perspectives are discussed. Graduate Staff

SOC 652 Comparative Societies. *Preq.: Six hrs. SOC. 3(3-0).* Sociological analysis of societies around the world with particular reference to North and South America. Special emphasis given to cultural and physical setting, population composition, levels of living, relationship of the people to the land, structure and function of the major institutions and forces making for change. Graduate Staff

SOC 655 Theory Construction. *Preq.: SOC 511 or equivalent. 3(3-0).* Provides students with a capability to develop theoretical frames of reference within which to devise and implement research activities. Acquaints students with the philosophical and disciplinary bases of theory, establishes the relationship between theory and research and enables objective evaluation of theoretical positions encountered in the literature. Graduate Staff

SOC 671 Social Demography. *Preq.: SOC 509 or 631 or equivalents. 3(3-0).* The basic purpose of this course is to develop on the part of the student an appreciation of the sociological variables capable of being used in demographic research and to provide an overview of the current substantive knowledge concerning social and demographic systems, social action systems and social aggregate systems. Graduate Staff

SOC 690 Seminar. *Credits Arranged.* Appraisal of current literature; presentation of research papers by students; progress reports on departmental research; review of developing research methods and plans; reports from scientific meetings and conferences; other professional matters. Graduate Staff

SOC 699 Research in Sociology. *Preq.: Consent of chair of graduate study committee. Credits Arranged.* Planning and execution of research and preparation of manuscript under supervision of graduate committee. Graduate Staff

Speech-Communication

SP 556 Seminar in Organizational Communication. *Preq.: Advanced undergrad. or grad. standing. 3(3-0)* S. Theoretic and applied approaches for studying communication perspectives of organizational behavior. Topics relate communication with organizational theories, research methods, leadership, power, attraction, conflict and theory development.

Soil Science

GRADUATE FACULTY

Professor E. J. Kamprath, Acting Head

Professors: S. W. Buol, D. K. Cassel, M. G. Cook, F. R. Cox, G. A. Cummings, C. B. Davey, J. W. Gilliam, W. A. Jackson, L. D. King, G. S. Miner, C. D. Raper Jr., P. A. Sanchez, E. D. Seneca, R. W. Skaggs, R. J. Volk, J. B. Weber, S. B. Weed, A. G. Wollum II; *Professor (USDA):* D. W. Israel; *Extension Professors:* J. V. Baird, J. P. Zublena; *Visiting Professors:* D. E. Bandy, M. D. Openshaw; *Professors Emeriti:* W. V. Bartholomew, R. W. Cummings, J. W. Fitts, C. B. McCants, J. A. Phillips, W. G. Woltz, W. W. Woodhouse Jr.; *Associate Professors:* H. L. Allen Jr., A. Amoozegar, S. W. Broome, M. T. Hoover, G. D. Hoyt, H. J. Kleiss, R. Lea, J. P. Lilly, J. E. Shelton, M. J. Vepraskas; *Extension Associate Professor:* G. C. Naderman; *Adjunct Associate Professor:* D. W. Eaddy; *Associate Professor Emeritus:* R. E. McCollum; *Assistant Professor:* T. J. Smyth; *Visiting Assistant Professor:* J. C. Alegre; *Assistant Professor Emeritus:* C. K. Martin; *Senior Researcher:* W. P. Robarge; *Visiting Lecturer:* R. B. Daniels

The Department of Soil Science offers graduate programs leading to the Master of Science and Doctor of Philosophy degrees. These are research-oriented degrees and require a thesis/dissertation based on individual research on some aspect of the science. In addition, the Master of Agriculture degree (non-thesis) may be obtained through the department.

Each M.S. and Ph.D. student will participate in one of many active research projects supervised by personnel in the department. The research may be specialized in one of the traditional sub-disciplines, e.g., soil chemistry or it may inte-

grate subject matter from related disciplines to address current societal needs, *e.g.*, waste management. Several of the projects are interdepartmental in character and, thus, a student may develop a particularly strong supportive program in one of the cooperating departments.

The department provides opportunities for students to tailor their programs for careers in research, teaching, extension or international programs. A student interested in one of these areas is encouraged to add this special dimension to the research emphasis required of all students. Arrangements for these opportunities are made on an individual basis with appropriate faculty.

FOR GRADUATES AND ADVANCED UNDERGRADUATES

SSC 501 Tropical Soils: Characteristics and Management. *Preqs.: Six credits in SSC. 3(3-0) S.* Characteristics of the tropical environment. Distribution and classification of tropical soils. Soil-plant relationships in the tropics. Soil management systems emphasizing shifting cultivation, flooded rice production, subsistence farming and tropical pasture management. Sanchez

SSC 511 Soil Physics. *Preqs.: SSC 200, PY 212. 4(3-3) F.* The study of soil physical properties and theory of selected instrumentation to measure them. Topics include soil solids, soil water, air and heat. Transport processes and the energy concept of soil and water are emphasized. Cassel

SSC 520 Soil and Plant Analysis. *Preqs.: PY 212; CH 315; at least three soils courses including SSC 341 or CI. 3(2-3) S. Alt. yrs.* Theory and advanced principles of the utilization of chemical instruments to aid research on the heterogeneous systems of soils and plants. Gilliam

SSC 522 Soil Chemistry. *Preqs.: SSC 200, one yr. of general inorganic chemistry. 3(3-0) S.* A consideration of the chemical and colloidal properties of clay and soil systems, including ion exchange and retention, soil solution reactions, solvation of clays and electrokinetic properties of clay-water systems. Weed

SSC (MB) 532 Soil Microbiology. *Preqs.: MB 401; CH 220 or CI. 4(3-3) S.* Soil as a medium for microbial growth, the relation of microbes to important mineral transformations in soil, the importance of biological equilibrium and significance of soil microbes to environmental quality. Wollum

SSC 541 Soil Fertility. *Preqs.: SSC 341. 3(3-0) F.* Soil conditions affecting plant growth and the chemistry of soil and fertilizer interrelationships. Factors affecting the availability of nutrients. Methods of measuring nutrient availability. Kamprath

SSC 551 Soil Morphology, Genesis and Classification. *Preqs.: MEA 120, SSC 200, SSC 341. 3(3-0) F.* Morphology: Chemical, physical and mineralogical parameters useful in characterizing soil. Genesis: Soil-forming factors and processes. Classification: Historical development and present concepts of soil taxonomy with particular reference to worldwide distribution of great soil groups as well as discussions of logical bases of soil classification. Buol

SSC 553 Soil Mineralogy. *Preqs.: SSC 200, SSC 341, MEA 330. 3(2-3) F. Alt. yrs.* Composition, structure, classification, identification, origin, occurrence and significance of soil minerals with emphasis on primary weatherable silicates, layer silicate clays and sesquioxides. Weed

SSC 560 Advanced Soil Management. *Preqs.: SSC 200, 341. 3(3-0) Sum. Alt. yrs.* Studies of soil characteristics in the coastal plain, piedmont and mountain areas of North Carolina. Discussion of management practices that should be associated with various soils for different types of enterprises. Two overnight field trips required. Graduate Staff

SSC 590 Special Problems. *Preq.: SSC 200. Credits Arranged. F, S.* Special problems in various phases of soils. Emphasis placed on review of recent and current research.

Graduate Staff

FOR GRADUATES ONLY

SSC (CS, HS) 614 Herbicide Behavior in Plants and Soils. *3(3-0) F.* (See crop science.)

SSC 651 Pedology. *Preqs.: SSC 522, 511; SSC 551 or equivalent. 3(3-0) S. Alt. yrs.* A critical study of current theories and concepts in soil genesis, morphology and classification.

Buol

SSC (BAE) 671 Theory of Drainage—Saturated Flow. *3(3-0) F. Alt. yrs.* (See biological and agricultural engineering.)

SSC 672 Soil Properties and Plant Development. *Preqs.: BCH 551, SSC 522 or equivalent. 3(3-0) S. Alt. yrs.* An examination of the interrelationships of soil properties and plant characteristics which regulate inorganic ion accumulation and dry matter production in higher plants.

Jackson

SSC (FOR) 673 Forest Productivity: Edaphic Relationships. *3(2-3) F. Alt. yrs.* (See forestry.)

SSC (BAE) 674 Theory of Drainage—Unsaturated Flow. *3(3-0) S. Alt. yrs.* (See biological and agricultural engineering.)

SSC 690 Seminar. *Preq.: Grad. standing in SSC. 1(1-0) F, S.* A maximum of two semester hours allowed toward the master's degree, but any number toward the doctorate. Scientific articles, progress reports in research and special problems of interest to soil scientists reviewed and discussed.

Graduate Staff

SSC 693 Colloquium in Soil Science. *Preq.: Grad. standing in SSC. Credits Arranged. F, S.* Seminar-type discussions and lectures on specialized and advanced topics in soil science.

Graduate Staff

SSC 699 Research. *Preq.: Grad. standing in SSC. Credits Arranged. F, S.* A maximum of six semester hours allowed toward the master's degree but any number towards the doctorate.

Graduate Staff

Solid State Sciences

GRADUATE FACULTY

Professor G. Lucovsky, Chair

Professors: K. J. Bachmann, S. M. Bedair, R. F. Davis, R. E. Fornes, J. R. Hauser, J. J. Hren, M. A. Littlejohn, J. Narayan, G. Rozgonyi, D. E. Sayers, J. F. Schetzina, A. F. Schreiner, E. O. Stejskal, M. H. Whangbo, J. J. Wortman; *Associate Professors:* J. Bernholc, R. M. Kolbas, R. J. Nemanich, M. A. Paesler, P. E. Russell; *Assistant Professor:* G. A. Ruggles

The university offers courses of study leading to a minor in solid state sciences as part of the Master of Science and the Doctor of Philosophy degrees. This option is available to all graduate students pursuing research in the broad area of solid

state science and requires that a member of the solid state sciences faculty serve on the student's research committee.

Solid state sciences is an interdisciplinary area of research that applies and extends concepts from the traditional academic disciplines of chemistry, electrical and computer engineering, materials science and engineering, and physics to basic and applied problems with a primary focus on solid state materials. At NCSU, there are a significant number of such research programs that involve faculty and students in more than one of the academic departments listed above. This minor program can be customized to provide a course complement for these ongoing programs, as well as for any additional solid state materials research programs as they are initiated, developed and implemented.

To fulfill the academic requirements for a minor in solid state sciences, each master's student must successfully complete at least three, and each doctoral student, four of the courses in the solid states sciences curriculum. A partial listing of courses in this program includes: CH 501, 503 Advanced Inorganic Chemistry I, II; CH 531, 631 Chemical Thermodynamics I, II; CH 533 Chemical Kinetics; CH 537 Quantum Chemistry; ECE 530 Physical Electronics; ECE 539 Integrated Circuit Technology and Fabrication; ECE 623 Optical Properties of Semiconductors; ECE 624 Electronic Properties of Solid State Devices; ECE (PY) 627 Semiconductor Thin Films Technology; MAT 512 Scanning Electron Microscopy; MAT 515 Fundamentals of Transmission Electron Microscopy; MAT 560 Materials Science and Processing of Semiconductor Devices; MAT 595 Advanced Materials Experiments; MAT 612 Advanced Scanning Electron Microscopy and Surface Analysis; MAT 660 Defects, Diffusion and Ion Implantation in Semiconductors; MAT 692 Advanced Topics in Materials Science and Engineering; PY (ECE) 552, 553 Introduction to the Structure of Solids I, II. In addition, other courses (for example, special topics courses in any one of the participating departments) may also be substituted into an individual student's designated solid state sciences minor program at the discretion of his/her committee.

Special Education

For information on this program, see curriculum and instruction under education.

Statistics

GRADUATE FACULTY

Professor D. L. Solomon, Head

Professor T. M. Gerig, Graduate Administrator

Professors: B. B. Bhattacharyya, P. Bloomfield, D. D. Boos, C. C. Cockerham, D. A. Dickey, A. R. Gallant, F. G. Giesbrecht, H. J. Gold, T. Johnson, K. H. Pollock, C. H. Proctor, C. P. Quesenberry, J. O. Rawlings, D. L. Ridgeway, W. H. Swallow, H. R. van der Vaart, J. L. Wasik, B. S. Weir, O. Wesler; *Adjunct*

Professors: M. W. Anderson, J. R. Chromy, A. L. Finkner, J. H. Goodnight, A. R. Manson, R. L. Obenchain; *Professors Emeriti:* A. H. E. Grandage, R. J. Hader, D. W. Hayne, D. D. Mason, R. J. Monroe, L. A. Nelson, J. A. Rigney, R. G. D. Steel; *Associate Professors:* R. L. Berger, C. Brownie, E. J. Dietz, S. P. Ellner, A. C. Linnerud, J. F. Monahan, D. W. Nychka, S. G. Pantula, T. W. Reiland, C. E. Smith, L. A. Stefanski; *Associate Professor (USDA):* K. P. Burnham; *Adjunct Associate Professors:* B. G. Cox, W. W. Piegorsch; *Assistant Professors:* M. Davidian, J.-C. Lu

ASSOCIATE MEMBERS OF THE DEPARTMENT

Professors: W. R. Atchley, M. M. Goodman, W. L. Hafley, V. K. Smith; *Associate Professor:* T. H. Emigh; *Assistant Professor:* A. R. Hall

The Department of Statistics offers programs leading to the Master of Science and Doctor of Philosophy degrees in both statistics and biomathematics and to the Master of Statistics and Master of Biomathematics degrees. It also offers co-major and joint Ph.D. programs with other departments including economics and business, crop science, genetics, biomathematics, operations research, forestry and computer studies. Flexible minor programs in statistics are offered at the Master's and Ph.D. levels. With a graduate faculty of 36 representing virtually all major statistical specializations, the department is recognized as a world leader in graduate education and research in statistics. Its applied orientation sets it apart from most other departments in the country, offering training to those wishing to pursue careers as consulting statisticians in industry and government as well as to those seeking careers in research and teaching.

Areas of research specialization of the faculty and advanced graduate students include time series, biomathematics, econometrics, quantitative genetics and ecology, experimental design and analysis, multivariate analysis, sampling, life science applications, quality control, statistical computing, nonparametric regression, robust and nonparametric inference, mathematical programming, Bayesian inference, decision theory and stochastic processes.

The department provides consulting services to many other departments. This function places the department in a unique position in the University community, offering opportunities for collaboration and providing students with hands-on consulting experiences.

In addition to its ongoing program, the department houses three special groups. The Biomathematics Graduate Program, which is described under biomathematics, offers its own degrees and supports a research program. The Quantitative Genetics Research Program is an internationally respected research group of faculty, post-doctoral fellows and graduate students. The Southeastern Cooperative Fish and Game Statistics Project provides statistical consulting services to wildlife agencies in the southeast. Training and research in wildlife statistics are supported through this project.

The well-prepared applicant to the department's Master's program has good grades in a three-semester calculus sequence, a two-semester advanced calculus sequence, a semester of linear algebra and a two-semester sequence in probability and statistics. Some of these courses may be taken as part of the program but this may result in lengthening the stay. Admission to our Ph.D. program is

granted to students who have passed the departmental Basic Comprehensive Examination at the Ph.D. level. A suitably prepared student can complete the Master's degree in two years. The Ph.D. usually requires three years beyond the Master's.

Departmental assistantships and fellowships are awarded each year on a competitive basis. Fellowships are provided through the Department's Gertrude M. Cox Fellowship Fund. Approximately 25 teaching assistantships and 25 research assistantships are also available.

Extensive library facilities are available in the area including the University's D. H. Hill Library, the Statistics departmental library, and those at Duke University and the University of North Carolina at Chapel Hill.

The department provides extensive computing support for its students. The department computing laboratory houses terminals and IBM-PC and PC/AT microcomputers, as well as graphics terminals (Tektronix 4105 and Vectrix VX 384) and an 8-pen plotter (Tex 4662A). The department data switch provides access to remote and local computing facilities, as well as the D. H. Hill Library Bibliographic Information System (BIS). A powerful remote computer is the IBM 3081 (Model K) located at the Triangle Universities Computer Center; the NCSU Computer Center operates an IBM 4381 using CMS. The department DEC VAX 11/750 provides interactive computing and graphics in a VMS/EUNICE (UNIX emulator) environment. Software, languages and statistical packages available on the IBM systems include SAS, IMSL, SPSS, Fortran, APL and Pascal, among many others; on the VAX, Fortran, C, S and the graphics system DI-3000 are available.

Currently, employment opportunities are excellent for statisticians trained at all levels. The department regularly receives notification of job openings from industry, government and academic institutions. The National Science Foundation predicts a shortage of statisticians in the coming years.

SELECTED ADVANCED UNDERGRADUATE COURSES

ST 421, 422 Introduction to Mathematical Statistics. *Preq.: (421) MA 202 or MA 212; (422) ST 421. 3(3-0) F,S.*

ST 430 Introduction to Regression Analysis. *Preq.: ST 302. 3(3-0) F.*

ST 431 Introduction to Statistics. *Preq.: ST 372 or ST 402. 3(3-0) S.*

ST 435 Statistical Methods for Quality and Productivity. *Preq.: ST 302. 3(3-0) F.*

ST 445 Introduction to Statistical Computing and Data Management. *Preq.: ST 302. 3(3-0) S.*

ST 493 Special Topics in Statistics. *Preq.: CI. 1-3 F,S,Sum.*

FOR GRADUATES AND ADVANCED UNDERGRADUATES

ST 505 Applied Nonparametric Statistics. *Preq.: ST 372 or ST 511. 3(3-0) S.* Statistical methods that require relatively mild assumptions about the form of the population distribution. Hypothesis testing, point and interval estimation and multiple comparison procedures for a variety of statistical problems.

Dietz

ST (ZO) 506 Sampling Animal Populations. *Preq.: ST 512. 3(3-0) F. Alt. yrs.* Statistical methods applicable to sampling of wildlife populations, including capture-recapture, removal, change in ratio, quadrat and line transect sampling. Emphasis on model assumptions and study design. Pollock

ST 507 Statistics for the Behavioral Sciences I. *3(3-0) F.* A general introduction to the use of descriptive and inferential statistics in behavioral science research. Methods for describing and summarizing data presented, followed by procedures for estimating population parameters and testing hypotheses concerning the summarized data. Dietz, Gold, Swallow, Wasik

ST 508 Statistics for the Behavioral Sciences II. *Preq.: ST 507 or CI. 3(3-0) S.* The use of statistical design principles in behavioral science research introduced. The use of a statistical model to represent the structure of data collected from a designed experiment or survey study presented. Opportunities provided for use of a computer to perform analyses of data, to evaluate the proposed statistical model and to assist in post-hoc analysis procedures. Least squares principles used to integrate the topics of multiple linear regression analysis, the analysis of variance and analysis of covariance. Swallow, Wasik

ST 511 Experimental Statistics for Biological Sciences I. *Preq.: ST 311 or grad. standing. 3(3-0) F,S.* Basic concepts of statistical models and use of samples; variation, statistical measures, distributions, tests of significance, analysis of variance and elementary experimental design, regression and correlation, chi-square. Graduate Staff

ST 512 Experimental Statistics for Biological Sciences II. *Preq.: ST 511 or equivalent. 3(3-0) F,S.* Covariance, multiple regression, curvilinear regression, concepts of experimental design, factorial experiments, confounded factorials, individual degrees of freedom and split-plot designs. Graduate Staff

ST 514 Experimental Statistics for Social Sciences II. *Preq.: ST 507 or equivalent. 3(3-0) S.* Extension of basic statistical concepts to computer handling of data from social surveys; sample designs using clustered, stratified, systematic and multi-stage selections; analysis of variance continued; multiple, multivariate regression. Johnson, Proctor

ST 515, 516 Experimental Statistics for Engineers. *Preq.: (515) ST 361 or grad. standing; (516) ST 515. 3(3-0) F,S.* General statistical concepts and techniques useful to research workers in engineering, textiles, wood technology, etc. Probability distributions, measurement of precision, simple and multiple regression, tests of significance, analysis of variance, enumeration data and experimental designs. Nychka, Quesenberry

ST 517 Applied Least Squares. *Preq.: ST 402 or equivalent. 3(3-0) F.* Least squares estimation and hypothesis testing procedures for linear models. Regression, analysis of variance and covariance considered in a unified manner that requires no extensive mathematical background. Emphasis on the use of the computer to apply these techniques to experimental (including unequal cell sizes) and survey situations. Rawlings

ST 518 Applied Time Series Analysis. *Preq.: ST 512. 3(3-0) F.* An introduction to the use of statistical methods for analyzing and forecasting data observed over time. Trigonometric regression, periodogram/spectral analysis. Smoothing. Autoregressive moving average models. Regression with autocorrelated errors. Linear filters and bivariate spectral analysis. Methods and applications stressed; software implementations described and used in assignments. Bloomfield, Dickey, Monahan, Pantula

ST 519 Applied Multivariate Statistical Analysis. *Preq.: ST 512 or equivalent. 3(3-0) S.* An introduction to the use of multivariate statistical methods in the analysis of data collected in experiments and surveys. Topics covered include multivariate analysis of variance, discriminant analysis, canonical correlation analysis and principal components analysis. The use of a computer to perform the multivariate statistical analysis calculations emphasized. Gerig, Monahan

ST 521 Statistical Theory I. *Coreqs.: MA 425 or MA 511 and MA 405. 3(2-2) F.* Discussion of the use of statistics as illustrated by an example pointing out the need for a probabilistic framework. The probability tools for statistics: description of discrete and absolutely continuous distributions, expected values, moments, moment generating functions, transformation of random variables, marginal and conditional distributions, independence, order statistics, multivariate distributions, concept of random sample, derivation of many sampling distributions. Berger

ST 522 Statistical Theory II. *Preq.: ST 521; Coreq.: MA 426 or MA 512. 3(2-2) S.* General framework for statistical inference. Point estimators: biased and unbiased, minimum variance unbiased, least mean square error, maximum likelihood and least squares, asymptotic properties. Interval estimators and tests of hypotheses: confidence intervals, power functions, Neyman-Pearson lemma, likelihood ratio tests, unbiasedness, efficiency and sufficiency. Berger

ST 531 Design of Experiments. *Preq.: ST 402 or equivalent. 3(3-0) F.* Review of completely randomized, randomized complete block and Latin square designs and the basic concepts in the techniques of experimental design. Designs and analysis methods in factorial experiments, confounded factorials, response surface methodology, change-over design, split-plot experiments and incomplete block designs. Examples used to illustrate application and analysis of these designs. Giesbrecht, Swallow

ST 535 Statistical Quality Control. *Preq.: ST 515. 3(3-0) F. Alt. yrs.* Modern quality control for students with a calculus-level prerequisite course in engineering statistics. Emphasis upon on-line QC methods including classic charting techniques and modern methods for automated control of processes. Off-line QC topics include methods for sampling inspection and topics from experimental design applied to parameter and allowance design. Quesenberry

ST (MA) 541 Theory of Probability I. *3(3-0) F.* (See mathematics.)

ST (MA) 542 Introduction to Stochastic Processes. *Preqs.: MA 405 and MA 541 or ST 521. 3(3-0) S.* Markov chains and Markov processes, Poisson process, birth and death processes, queuing theory, renewal theory, stationary processes, Brownian motion. Bhattacharyya, Wesler

ST 550 Intermediate Statistical Methods. *Preqs.: ST 512 and ST 522. 3(3-0) F.* Introduction to statistical models and methodologies for survival analysis (parametric and non-parametric), bioassay, logistic regression and categorical data analysis (log-linear model and weighted least squares approaches). Software implementations described and used in assignments. Stefanski, Gerig

ST (EB) 561 Intermediate Econometrics. *3(3-0) S.* (See economics and business.)

ST (TOX) 563 Statistical Problems in Toxicology. *Preq.: ST 511 or equivalent. 2(2-0) S. Alt. yrs.* Introduction to statistical issues arising in toxicological research, including review of standard statistical techniques. Special topics include teratological and short-term mutagenicity studies, long-term cancer bioassays, epidemiology, risk assessment and the use of historical controls. Brownie

ST (BMA, MA) 571 Biomathematics I. *3(3-0) F.* (See biomathematics.)

ST (BMA, MA) 572 Biomathematics II. *3(3-0) S.* (See biomathematics.)

ST (BMA, OR) 575 Decision Analytic Modeling. *Preqs.: MA 421 or ST 421 plus ST 511 or ST 516. 4(3-2) F. Alt. yrs.* Analysis of decision problems involving risk and uncertainty. Modeling the decision process; Bayesian probability analysis, use of information, and subjective probability; utility theory and multiattribute utility assessment; dynamics of interacting with decision makers and subject matter specialists; decision trees, influence

diagrams and other tools to assist in modeling decision problems. Laboratory develops skill in implementing the methodology. Gold

ST 581 Robust and Nonparametric Statistics. *Preq.: ST 522. 3(3-0) S. Alt. yrs.* Theory and methods for standard inference problems where the normal distribution may not correctly describe the error distribution. Topics include rank and order statistics, permutation methods, bootstrap, jackknife, Pitman efficiency, influence curve, breakdown point, M-estimation and minimum distance estimation. Boos

ST 583 Introduction to Statistical Decision Theory. *Preq.: ST 522. 3(3-0) F. Alt. yrs.* Zero sum two-person games and statistical inference. Bayesian methods and orthodox statistical estimation and testing; minimax decision rules; empirical Bayes procedures; Bayes sequential decision procedures. Berger, Bhattacharyya, Monahan

ST 591 Special Problems. *Preq.: CI. 1-3 F,S,Sum.* Development of techniques for specialized cases, particularly in connection with thesis and practical consulting problems. Graduate Staff

ST 595 Statistical Consulting. *Preqs.: ST 512 and ST 522. 1(1-1) F,S,Sum.* Participation in regularly scheduled supervised statistical consulting sessions with faculty member and client. Consultant's report written for each session. Regularly scheduled meetings with course instructor and other student consultants to present and discuss consulting experiences. Brownie

FOR GRADUATES ONLY

ST (MA, OR) 606 Nonlinear Programming. *Preqs.: OR (IE, MA) 505 and MA 425 or equivalent. 3(3-0) F.* This course provides an advanced mathematical treatment of the analytical and algorithmic aspects of finite dimensional nonlinear programming. It includes an examination of the structure and effectiveness of computational methods for unconstrained and constrained minimization. Special attention directed toward current research and recent developments in the field. Peterson, Reiland

ST (BMA, MA, OR) 610 Stochastic Modeling. *3(3-0) S. Alt. yrs.* (See biomathematics.)

ST 613 Time Series Analysis: Time Domain. *Preqs.: ST 512 and ST 522. 3(3-0) S. Alt. yrs.* Estimation inference for coefficients in autoregressive, moving average and mixed models and large sample. Distribution theory for autocovariances and their use in identification of time series models. Stationarity and seasonality. Extensions of theory and methods to multiple series including vector autoregressions, transfer function models, regression with time series errors, state space modeling. Dickey, Pantula

ST 614 Time Series Analysis: Frequency Domain. *Preqs.: ST 512 and ST 522. 3(3-0) S. Alt. yrs.* Theory and methods of time series analysis from the frequency point of view. Harmonic analysis, complex demodulation and spectrum estimation. Frequency domain structure of stationary time series and space-time processes. Sampling distributions of commonly used statistics. Bloomfield

ST (MA) 617, 618 Measure Theory and Advanced Probability. *Preqs.: (617) MA 426; ST 521 or MA 541 or equivalent; (618) ST 617. 3(3-0) F,S.* Modern measure and integration theory in abstract spaces. Probability measures, random variables, expectations. Distributions and characteristic functions. Modes of convergence. Independence, zero-one laws, laws of large numbers, three-series theorem. Central limit problem. Conditional expectations, martingales and martingale convergence theorems. Bhattacharyya, Wesler

ST 623 Statistics in Plant Science. *Preq.: ST 512 or equivalent. 3(3-0) F.* Principles and techniques of planning, establishing and executing field and greenhouse experiments. Size, shape and orientation of plots; border effects; estimation of size of experiments for specified accuracy; subsampling plots and yields for laboratory analysis; combining data from a

series of years and/or locations; rotation experiments; soil test correlation; multiple comparisons in variety trial results; selection of predictors in multiple regression; introduction to interspecies and intraspecies plant competition experiments and models.

Graduate Staff

ST (GN) 626 Statistical Concepts in Genetics. *Preqs.: GN 506; Coreq.: ST 402 or equivalent. 3(3-0) S. Alt. yrs.* Migration, mutation, selection, drift, linkage, mating system and other processes that bear on rates of change in population frequencies, means and variances; magnitude and nature of genotypic and nongenotypic variability and their role in alternative procedures of plant and animal breeding; experimental and statistical approaches to the analysis of quantitative inheritance.

Cockerham

ST 631 Theory of Sampling Applied to Survey Design. *Preqs.: MA 214 or equivalent; ST 402 or equivalent. 3(3-0) F.* Principles for interpretation and design of sample surveys. Estimator biases, variances and comparative costs. Simple random sample, cluster sample, ratio estimation, stratification, varying probabilities of selection. Multi-stage, systematic and double sampling. Response errors.

Pollock, Proctor

ST 637 Advanced Statistical Inference. *Preqs.: ST 522, ST 617. 3(3-0) S.* This course treats the classical areas of statistical inference, estimation and hypothesis testing, at the measure-theoretical level. Emphasis upon treatment of these areas in depth.

Graduate Staff

ST 639 Large Sample Theory. *Preq.: ST 522. 3(3-0) F. Alt. yrs.* Use of classical probability theorems to prove consistency and asymptotic distribution results for a wide variety of sample statistics. Examples of such statistics include maximum likelihood estimators, quadratic form test statistics and regression coefficients.

Boos

ST 645 Statistical Computing. *Preq.: ST 681. 3(3-0) F. Alt. yrs.* The intent of the course is to provide the statistician with the computational tools for statistical research and applications using digital computing machinery. Topics to be covered include random number generation and Monte Carlo methods, regression computations and application to statistical methods of optimization, sorting and Fast Fourier transform.

Monahan

ST (EB) 651 Econometrics. *3(3-0) F.* (See economics and business.)

ST (EB) 652 Topics in Econometrics. *3(3-0) S.* (See economics and business.)

ST 671 Advanced Analysis of Variance and Variance Components. *Preqs.: ST 402 or equivalent, ST 681. 3(3-0) S. Alt. yrs.* Expected mean squares, exact and approximate tests of hypotheses for balanced and unbalanced data sets. Fixed, mixed and random models. Randomization theory. Estimation of variance components using regression, MINQUE and general quadratic unbiased estimation theory.

Giesbrecht

ST 674 Advanced Topics in Construction and Analysis of Experimental Designs. *Preqs.: ST 402 or equivalent, ST 681. 3(3-0) S. Alt. yrs.* Construction and analysis of multifactorial designs, factorials, fractional factorials, balanced incomplete block designs, Latin squares, orthogonal arrays of strength d and response surface designs. Fractionating mixed level factorials, confounding and blocking techniques, study of robustness of designs to loss of design point.

Giesbrecht

ST 681 Linear Models and Variance Components. *Preqs.: MA 405, ST 521; Coreq.: ST 522. 3(2-2) S.* Theory of estimation and testing in full and non-full rank linear models. Normal theory distributional properties. Least squares principle and the Gauss-Markoff theorem. Estimability and properties of best linear unbiased estimators. The general linear hypothesis. Application of dummy variable methods to elementary classification models for balanced and unbalanced data. Analysis of covariance. Variance components estimation for balanced data.

Pantula

ST 682 Multivariate Linear Models and Nonlinear Models. *Preqs.: ST 512, ST 681. 3(3-0) F.* Inference for the multivariate general linear model. Normal theory distributional properties. Wishart matrices, Wilks' lambda criterion and Roy's maximum root test. Univariate and multivariate nonlinear models. Modified Gauss-Newton method for obtaining estimates. Asymptotic properties of estimators. Inference through the likelihood ratio test, the Lagrange multiplier test and the Wald test. Applications using computer implementation. Gallant

ST 683 Multivariate Analysis. *Preqs.: ST 522 and ST 682. 3(3-0) S. Alt. yrs.* Survey of multivariate statistical theory. Multivariate distributions including the multinormal, Wishart, Hotelling's T^2 , Fisher-Roy-Hsu, Wilks' V and multivariate Beta distributions. Applications of maximum likelihood estimation, likelihood ratio testing and the union-intersection principle. Development of the theory of Hotelling's T^2 tests and confidence sets, discriminant analysis, canonical correlation, multivariate analysis of variance and principal components. Gerig, Monahan

ST 691 Advanced Special Problems. *Preqs.: ST 402 or equivalent, ST 681. 1-3 F,S,Sum.* Any new advance in the field of statistics which can be presented in lecture series as unique opportunities arise. Graduate Staff, Visiting Professors

ST 694 Seminar. *1(1-0) F,S.* Graduate Staff

ST 699 Research. *Credits Arranged. F,S,Sum.* Graduate Staff

Textiles

Professor R. A. Barnhardt, Dean

For a listing of Graduate Faculty and department information, see Textile Engineering, Chemistry and Science, and Textile and Apparel Management.

The College of Textiles offers programs leading to the Master of Science degree in textile chemistry and in textiles with specializations in engineering and science and in management and technology, the professional degree of Master of Textiles and the Doctor of Philosophy in fiber and polymer science. (See fiber and polymer science for a description of the program.) The College of Textiles also participates in the Master of Science in management program in which students combine studies in the Department of Economics and Business with courses from the Department of Textile and Apparel Management (see management).

Students otherwise meeting the requirements of the Graduate School and with Bachelor of Science degrees with majors in textiles, management, or business administration (with adequate preparation in chemistry, physics and mathematics), the physical sciences or engineering will normally qualify for the graduate degree programs.

The minimum requirement for a Master of Textiles degree is the satisfactory completion of 33 semester hours of advanced courses. There is no thesis or foreign language requirement. This program offers the student advanced professional training with emphasis on management, CAD/CAM quality or manufacturing control, technology, machine design or textile design.

The programs of study for the Master of Science degree include a minimum of 30 semester hours of advanced courses, including six semester hours devoted to a thesis based on research conducted by the student. There is no foreign language requirement. The plan of course work and the research activities for the Master

of Science degree are designed to prepare the student for a career in research, development, management or other technical phases of the fiber textile, apparel and allied industries. Students may minor in one or more of a number of associated fields.

Programs of study may be arranged to develop a broad background in three general areas: advanced textile materials science, the engineering, technology and management of textile and apparel manufacturing processes; and textile chemistry. Students may carry out research on such topics as polymer and fiber chemistry; fiber, textile and apparel manufacturing; the physical and mechanical properties of fibers and textiles; textile dyeing and finishing; marketing and production management; engineering economics, information technology and quantitative decision making; etc.

Fiber and Polymer Science

See fiber and polymer science for a list of associated courses.

Textiles (General Courses)

SELECTED ADVANCED UNDERGRADUATE COURSES

T 401 Environmental Aspects of the Textile Industry. *Preq.: Sr. standing. 3(3-0) S.*

T 402 Introduction to the Theory and Practice of Fiber Formation. *Preqs.: CH 103, T 203, MA 212, PY 212. 3(3-0) S.*

T 491H Honors Seminar in Textiles. *By invitation into Honors Program in Textiles. 1(1-0) F,S.*

T 493 Industrial Internship in Textiles. *Preq.: Textile core courses. 3 F,S,Sum.*

Textile Engineering, Chemistry and Science

Professor C. D. Livengood, Head

Professor G. N. Mock, Assistant Head, Undergraduate Programs

Professor B. S. Gupta, Assistant Head, Graduate Programs

Professors: R. L. Barker, K. R. Beck, D. R. Buchanan, J. A. Cuculo, A. H. El-Shiekh, H. S. Freeman, R. D. Gilbert, P. L. Grady, S. P. Hersh, P. R. Lord, R. McGregor, M. H. Mohamed, M. H. Theil, C. Tomasino, P. A. Tucker; Adjunct Professors: J. E. Hendrix, T. Iijima, H. F. Mark, J. Preston, L. Roldan; Professors Emeriti: J. F. Bogdan, K. S. Campbell, D. M. Cates, P. D. Emerson, T. W. George, D. S. Hamby, J. A. Porter Jr, H. A. Rutherford, W. K. Walsh, W. M. Whaley, R. W. Work; Associate Professor: C. B. Smith; Adjunct Associate Professors: L. D. Claxton, P. E. Sasser; Associate Professors Emeriti: T. H. Guion, A. C. Hayes, T. G. Rochow; Assistant Professors: P. Banks-Lee, T. G. Clapp, H. Hamouda, S. M. Hudson, J. W. Rucker, G. W. Smith; Visiting Assistant Professor: T. K. Ghosh

ASSOCIATE MEMBERS OF THE DEPARTMENT

Professors: S. K. Batra, R. E. Fornes

The Department of Textile Engineering, Chemistry and Science offers the degree of Master of Science in textile chemistry, the degree of Master of Science in textiles with specialization in textile engineering and science, and the professional degree of Master of Textiles in both programs. The department embraces a number of disciplines including synthesis of polymers, formation of fibers, manufacturing of yarns and woven, knitted and nonwoven fabrics, and dyeing and finishing. The departmental offerings, in addition to including these technological areas, cover such scientific aspects as the characterization of the chemical, physical and mechanical properties of the materials and their structure, the underlying principles governing their properties, the structure-property relationships, the environmental effects, and the material-machine interactions. Students receive a fundamental knowledge of the principles that relate to this highly diversified and derivative field and an opportunity to conduct research in an area supporting it.

SELECTED ADVANCED UNDERGRADUATE COURSES

TC 407 Wet Processing and Quality Control. *Preqs.: T 250, TC 310, TC 320. 3(1-6) S.*

TC 412 Textile Chemical Analysis II. *Preq.: T 203. 3(2-3) S.*

TC 415 Principles and Practice of Textile Printing. *Preqs.: T 301 or TC 320 or PD(TX) 272. 3(2-2) F.*

TC 441 Theory of Physico-Chemical Processes in Textiles I. *Preqs.: C in MA 231 or 241; C in PY 205 or 211. 3(3-0) F.*

TC 442 Theory of Physico-Chemical Processes in Textiles II. *Preq.: TC 441. 3(3-0) S.*

TC 451 Computers in Textile Wet Processing. *Preqs.: MA 212, PY 212, T 301. 3(3-0) S.*

TC (CH) 461 Introduction to Fiber-Forming Polymers. *Preq.: CH 223. 4(3-3) F.*

TC 490 Special Topics in Textile Chemistry. *1-6 F,S.*

TC 491 Seminar in Textile Chemistry. *Preqs.: TC 320, TC 330 and sr. standing. 1(0-2) S.*

TT 405 Contemporary Nonwoven Textiles. *Preqs.: TES 305; sr. standing and CI. 3(3-0) S.*

TT 420 Modern Developments in Yarn Manufacturing. *Preq.: Sr. standing. 3(3-0) S.*

TT 425 Textured Yarn Production and Properties. *Preqs.: T 211, T 220, PY 211 (205); Coreq.: PY 212 (208). 3(2-2) F.*

TT 443 Advanced Knitting Systems and Fabrics. *Preq.: TT 341. 3(2-2) F.*

TT 450 Advanced Weaving. *Preq.: TES (TMT) 351. 3(2-2) F. Alt. yrs.*

TT 451 Advanced Woven Fabric Design. *Preq.: TES (TMT) 370. 3(2-2) S. Alt. yrs.*

TS 460 Physical Properties of Textile Fibers. *Preqs.: MA 212, PY 212. 3(3-0) F,S.*

TS 461 Mechanical Properties of Fibrous Structures. *Preqs.: MA 301, TES 460. 3(3-0) S.*

FOR GRADUATES AND ADVANCED UNDERGRADUATES

TC 504 Fiber Formation—Theory and Practice. *Preqs.: MA 301, PY 208 or CI. 3(3-0) F.* Practical and theoretical analysis of the chemical and physical principles underlying the conventional methods of converting bulk polymer to fiber; rheology; melt, dry and wet polymer extrusion; fiber drawing; heat setting; general theory applied to unit processes. Cuculo

TC 505 Theory of Dyeing. *Preq.: CH 433 or CI. 3(3-0) S.* Mechanisms of dyeing. Application of thermodynamics to dyeing systems. Kinetics of diffusion in dyeing processes. McGregor

TC 506 Color Science. *Preq.: Sr. or grad. standing in TC; Coreq.: TC 507. 3(3-0) F.* Basis of modern techniques for color specification, measurement, control and communication. Applications of color science to textiles, plastics, color reproduction, computer-based imaging and display systems. Basic concepts taught by computer color graphics. McGregor

TC 507 Color Laboratory. *Preq.: Sr. or grad. student in textile chemistry; Coreq.: TC 506. 1(0-2) F.* Exercises with modern methods and equipment to aid in understanding color perception, color science and color measurement. Computer color graphics exercises for comprehension of basic concepts. Independent projects in color science. Limited enrollment. Graduate Staff

TC 520 Chemistry of Dyes and Color. *Preqs.: CH 221 and CH 223. 3(3-0) S.* Correlation of color and chemical constitution, synthetic routes for popular dyes of all important types; electronic mechanisms for reactive dyes; chemistry of dye interactions with light, washing and other in-use influences; economic and environmental considerations. Freeman

TC 521 Dye Synthesis Laboratory. *Preq.: TC 520. 3(0-9) F.* Laboratory work in the preparation and analysis of synthetic dyes of a large number of types. Personal instruction in techniques and processes for preparation and purification of intermediates and dyes. Freeman

TC 530 The Chemistry of Textile Auxiliaries. *Preq.: One yr. of organic chemistry. 3(3-0) F.* Industrially important textile chemicals used for enhancing fiber and fabric properties such as durable press, water repellency, antisoiling, flame retardancy, softness, stiffness, lubricity and other uses will be studied. Correlation of effect with structure, end-use influences, interaction with fabric and fibers, sources and synthetic routes, economic and environmental considerations will be covered. Tomasino

TC (MAT) 561 Organic Chemistry of Polymers. *Preqs.: TC 461 and CH 231 or CH 431. 3(3-0) S.* Principles of step reaction and addition polymerizations; copolymerization; emulsion polymerization; ionic polymerization; characterization of polymers; molecular structure and properties. Gilbert, Theil

TC (CH, MAT) 562 Physical Chemistry of High Polymers—Bulk Properties. *Preqs.: CH 220 or CH 203, CH 431. 3(3-0) F. Alt. yrs.* Molecular weight description; states of aggregation and their interconversion; rubbery, glassy and crystalline states; rubber elasticity; diffusion properties. Cates

TC 565 Polymer Applications and Technology. *Preqs.: One yr. of organic chemistry; TC 461. 3(3-0) S.* Poly(olefins), poly(vinyl chloride), poly(vinyl acetate), poly(urethanes), epoxies, silicones, styrene copolymers used as textile finishes, nonwoven binders, fabric coatings, composites, adhesives, foams, carpet backing adhesives. Synthesis, industrial processes, properties and products are emphasized. Graduate Staff

TC (CHE) 569 Polymers, Surfactants and Colloidal Materials. *3(3-0) F.* (See chemical engineering.)

TC (CHE) 570 Radiation Chemistry and Technology of Polymeric Systems. *3(3-0) S.* (See chemical engineering.)

TC 591 Special Topics in Textile Science. *Preqs.: Sr. or grad. standing and CI. 1-4 F, S.* Intensive treatments of selected topics in textile, polymer and fiber science.

Graduate Staff

TES 500 Fiber and Polymer Microscopy. *Preqs.: MA 212, PY 212, T 203. 3(1-4) F.* The art and science of light and electron microscopy; theoretical and practical aspects of visibility, resolution and contrast. Laboratory practice in assembling, testing and using various microscopes and accessories in analyzing, describing and identifying unoriented and oriented crystalline or amorphous materials. Laboratory emphasis on the study of fibers and polymers through transmission microscopy with polarized light. Tucker

TES 505 Textile Instrumentation and Control Systems. *Preqs.: MA 301, PY 212 and one course in computer science. 3(3-0) F.* The theory and application of instruments and control systems used in modern textile plants. Basic instruments and computer systems are described along with their use in process control, production control, research and development. Grady

TES 520 Yarn Processing Dynamics. *Preqs.: MA 301 and CI or grad. standing. 3(2-2) F.* Theoretical analysis of the dynamics and machine-fiber interactions of such functions as opening, cleaning, carding actions, fiber attenuation, ring spinning, open-end spinning, texturing and winding. The role of fiber placement, cohesion and lubrication on yarn processing and properties. Laboratory experiments designed to verify the analysis discussed in the lectures. El-Shiekh

TES 541 Theory and Practice of Knitted Fabric Production and Control. *Preqs.: TT 370 and CI. 3(3-0) F.* The technology and control systems for manufacturing simple and complex knitted fabrics; control and monitoring of yarn feeding systems; influence of yarn, machine, finishing and fabric structure on the fabric aesthetics, physical and mechanical properties; optimization of fabric properties and machine productivity, including costing; problems of jacquard fabric processing and control. Graduate Staff

TES 549 Warp Knit Engineering and Structural Design. *Preq.: TT 443. 3(3-0) S.* Engineering analysis of trikot and raschel machinery. Design of yarn let-off and fabric take-up mechanisms. Studies of fabric production techniques and quality control systems. Theory of production optimization and the properties of fabrics. Complex geometrical loop models and their application. Graduate Staff

TES 555 Production Mechanics and Properties of Woven Fabrics. *Preqs.: MA 301 AND CI or grad. standing. 3(2-2). S.* The interrelations between the mechanics of production and mechanical properties of woven fabrics; unit operations required to prepare yarns for weaving and the mechanisms employed in weaving; fabric structure, geometry and mechanical properties; designing for specific fabric properties. Mohamed

TES 561 Mechanical and Rheological Properties of Fibrous Material. *Preq.: MA 301. 3(2-2) S.* In-depth study of the stress-strain, bending, torsional, dynamic and rheological behavior of natural and man-made fibers. Theoretical relations and advanced techniques are presented and discussed. Gupta, Hersh

TES (TMT) 562 Physical Properties of Fiber Forming Polymers, Fibers and Fibrous Structures. *Preqs.: MA 301, PY 208. 3(3-0) F.* Experimental results and theoretical considerations of the physical properties of fibers and fiber forming polymers discussed. This will include electrical, thermal, optical, frictional and moisture properties of these materials. The influence of chemical and molecular fine structure on these properties discussed. Buchanan, Gupta

TES (MAT) 563 Characterization of Structure of Fiber Forming Polymers. *Preqs.: MA 301, PY 208. 3(3-0) F.* Theories, experimental evidence and characterization methods of the molecular fine structure of fiber forming polymers in the solid state discussed. Characterization methods include X-ray diffraction, microscopy, infrared, thermal and magnetic resonance. An introduction to nucleation theory of polymer systems presented.
Buchanan, Gupta

TES 589 Special Studies in Textile Engineering and Science. *Preq.: Sr. or grad. standing. 1-4 F,S.* New or special course on developments in textile engineering and science. Specific topics and prerequisites identified vary. Generally used for first offering of a new course.
Graduate Staff

TES 590 Special Projects in Textile Engineering and Science. *Preqs.: Sr. standing or grad. standing. Cl. 2-3 F,S,Sum.* Advanced studies will include current problems of the industry, independent investigations, seminars and technical presentations, both oral and written.
Graduate Staff

FOR GRADUATES ONLY

TC (CH, MAT) 662 Physical Chemistry of High Polymers—Solution Properties. *Preqs.: CH 433, TC (CH, MAT) 562. 3(3-0) S. Alt. yrs.* Thermodynamics of polymer solutions; phase equilibria; methods determining of molecular weight.
Theil

TC (CHE) 669 Diffusion in Polymers. *2(2-0) S.* (See chemical engineering.)

TC (CHE) 671 Special Topics in Polymer Science. *1-3 F.* (See chemical engineering.)

TC (TES) 691 Special Topics in Fiber Science. *1-3 S.* (See textile engineering and science/textile management and technology.)

TC 698 Seminar for Textile Chemistry. *1(1-0) F,S.* Discussion of scientific articles and presentations; review and discussion of student papers and research problems.
Graduate Staff

TC 699 Textile Research for Textile Chemistry. *Credits Arranged.* Individual research in the field of textile chemistry.
Graduate Staff

TES 603 Group Research in Textiles. *Preqs.: TES 520 and TES 555 or TES (TMT) 541. 3(2-3) F.* Group research under supervision in which each student will execute a portion of the research and will report to the whole group. Each student required to write a report on the whole project. Formal lectures on methodology, interpretation and application of research.
Lord

TES 631 Synthetic Fibers. *Preq.: TT 425 or equivalent. 2(1-2) F,S,Sum.* Lectures and projects on advanced problems associated with the properties and processing of man-made continuous filament and staple fiber yarns.
Hersh

TES 640 Physical and Mechanical Properties of Knitted Fabric. *Preq.: TES 541. 3(3-0) Alt. S.* Seminar discussions of research literature on studies of the physical and mechanical properties of knitted fabrics.
Graduate Staff

TES 651, 652 Fabric Development and Construction. *Preq.: Grad. standing. 3(1-4) F,S.* Application of advanced technology to the development and construction of woven fabrics.
Graduate Staff

TES 663 Mechanics of Twisted Structures. *Preq.: TES 561 or equivalent. 3(3-0) S. Odd yrs.* Study of the basic mechanics of fibrous assemblies. Geometry and mechanics of twisted structures (yarns, cords, braids, etc.) and the translation of fiber properties into structural behavior.
Batra, El-Shiekh

TES 664 Mechanics of Fabric Structures. *Preq.: TES 561 or equivalent. 3(3-0) S. Even yrs.* Analysis of the geometry and behavior of woven, knitted and nonwoven fabrics under various stress conditions and end use applications. Batra, El-Shiekh

TES (TC) 691 Special Topics in Fiber Science. *Preq.: CI. 1-3 S.* The study of selected topics of particular interest in various advanced phases of fiber science. Graduate Staff

TES 697 Independent Study in Textiles. *3(3-0) F,S,Sum.* Problems of specific interest in textiles assigned for study and investigation. The preparation of a report for publication required. Three hours maximum credit allowed toward Master of Textiles degree. No credit allowed toward Master of Science in Textiles degree. Graduate Staff

TES 698 Seminar. *1(1-0) F,S.* Discussion of scientific articles of interest to the textile industry; review and discussion of student papers and research problems. Graduate Staff

TES 699 Textile Thesis or Dissertation Research. *Credits Arranged. F,S,Sum.* Problems of specific interest to the textile industry assigned for study and investigation. The use of experimental methods emphasized. Attention given to the preparation of reports for publication. The master's thesis may be based upon the data obtained. Graduate Staff

Textile and Apparel Management

Professor G. A. Berkstresser III, *Head*

Professor S. K. Batra, *Associate Head*

Professor: R. A. Barnhardt; *Professors Emeriti:* A. B. Moss, W. C. Stuckey; *Associate Professors:* R. A. Donaldson, P. B. Hudson, T. J. Little, M. A. Robinson Jr.; *Visiting Associate Professors:* N. A. Hunter, E. M. McPherson; *Adjunct Associate Professor:* D. M. Powell; *Assistant Professor:* A. C. Clapp

FOR GRADUATES AND ADVANCED UNDERGRADUATES

TAM 530 Textile Quality Control. *Preq.: TAM 330 OR CI. 3(3-0) S.* Quality control systems for textile operations with emphasis on sampling plans for attributes and variables and on interpretation of data as related to identifying sources of product variability. Graduate Staff

TAM (EB) 585 Market Research in Textiles. *Preq.: TAM (EB) 482. 3(3-0) S.* A study and analysis of the quantitative methods employed in market research in the textile industry. The function of market research and its proper orientation to management and decision making. Berkstresser

TAM 589 Special Studies in Textile Management and Technology. *Preq.: Sr. or grad. standing. 1-4 F,S.* New or special course on developments in textile management and technology. Specific topics and prerequisites vary. Graduate Staff

TAM 590 Special Projects in Textile Management and Technology. *Preqs.: Sr. standing or grad. standing. CI. 2-3 F,S,Sum.* Advanced studies on current problems of the industry, independent investigations, seminars and technical presentations, both oral and written. Graduate Staff

FOR GRADUATES ONLY

TAM 621 Advanced Textile Testing. *Preqs.: TAM 530; ST 421 or CI. 3(2-2) S.* Design of textile laboratories required for specific needs; experimental design and performance of tests; analysis of data relating to industrial problems; specialized physical tests; interlaboratory correlations; development of standardized test methods. Graduate Staff

TAM 680 Special Projects in Textile Management. *Preq.: TAM (EB) 585. 1-3 F,S,Sum.* Special studies in textile management covering current problems of the industry, independent investigations, seminars and technical presentations, both oral and written.
Graduate Staff

TAM 686 Advanced Textile Labor Management Seminar. *Preq.: TAM 487 or CI. 3(3-0) F,S.* A study of advanced labor management problems in the textile industry, with particular emphasis directed toward the application of the Occupational Safety and Health Act.
Powell

TAM 687 Competitive Strategy and Planning for the Textile Firm. *Preq.: Completion of 18 hrs. in a graduate degree program, of which at least 6 hrs. must be in economics and related courses at the 500 level or higher. 3(3-0). F.* Elements of competitive strategy and planning methods within the textile complex with emphasis on the concepts of strategy in a mature industry, defining business in a global industry, resource allocation through strategic planning methods and implementing strategy in single business and multi-business firms.
Hunter

TAM 697 Independent Study in Textiles. *3(3-0) F,S,Sum.* Problems of specific interest in textiles will be assigned for study and investigation. The preparation of a report for publication will be required. Three hours maximum credit will be allowed toward Master of Textiles degree. No credit is allowed toward Master of Science in Textiles degree.
Graduate Staff

TAM 698 Seminar. *1(1-0) F,S.* Discussion of scientific articles of interest to the textile industry; review and discussion of student papers and research problems.
Graduate Staff

TAM 699 Textile Thesis or Dissertation Research. *Credits Arranged. F,S,Sum.* Problems of specific interest to the textile industry assigned for study and investigation. The use of experimental methods emphasized. Attention given to the preparation of reports for publication. The master's thesis may be based upon the data obtained.
Graduate Staff

Toxicology

GRADUATE FACULTY

Professor E. Hodgson, Head

Assistant Professor R. C. Smart, Graduate Administrator

Professors: W. C. Dauterman, T. J. Sheets; Adjunct Professors: J. R. Fouts, J. A. Goldstein, R. M. Pilpot; Professor Emeritus: F. E. Guthrie; Adjunct Associate Professor: H. B. Matthews

ASSOCIATE MEMBERS OF THE DEPARTMENT

Professors: A. L. Aronson, W. E. Donaldson, P. B. Hamilton, H. M. Hassan, R. J. Kuhr, W. H. McKenzie, J. E. Riviere; Professors (USDA): W. W. Heck, D. E. Moreland; Adjunct Professor: M. W. Anderson; Professors Emeriti: D. S. Grosch, D. W. Hayne, R. J. Monroe; Associate Professors: K. B. Adler, C. F. Brownie, C. L. Robinette; Adjunct Associate Professor: T. E. Eling; Assistant Professors: J. M. Cullen, R. J. Linderman, N. A. Monteiro-Riviere, M. A. Qureshi

The Department of Toxicology offers courses of study leading to the Master of Toxicology, Master of Science and Doctor of Philosophy degrees. The Department of Toxicology trains qualified individuals to conduct basic and applied scientific research on the mechanisms of chemically induced toxicity, to advance toxicology as a science and to communicate concepts of toxicology. The department is associated with research organizations in the nearby Research Triangle Park, including the National Institute of Environmental Health Sciences, Environmental Protection Agency, Chemical Industry Institute of Toxicology and Burroughs Wellcome Foundation. Faculty research interests include biochemical toxicology; xenobiotic metabolism; chemical carcinogenesis; anticarcinogenesis; cutaneous toxicology; nutritional toxicology; neurotoxicology; mutagenesis; heavy metals; mycotoxins; oxygen toxicity; microbial degradation of toxicants; and toxicokinetics. Members of the toxicology faculty are drawn from other departments in the Colleges of Agriculture and Life Sciences, Veterinary Medicine and Physical and Mathematical Sciences.

The student is required to take graduate courses in toxicology (general, biochemical and environmental), pharmacology, biochemistry, pathology, statistics and epidemiology. A minimum of 30 credits are required for the Master of Science and 36 for the Master of Toxicology degrees, and a research thesis is required for the Master of Science. Doctor of Philosophy degree students must pass written and oral examinations after completing the second year of study and an original research thesis is required. Minors may be chosen from many programs including biochemistry, biotechnology, botany, entomology, epidemiology, genetics, microbiology, pharmacology, statistics and zoology.

Prospective students should have a strong background in the biological and physical sciences. Materials that must be submitted for admission to the Department of Toxicology are a completed application form, two copies of official transcripts from all colleges attended, three letters of reference, a letter of intent and results of the General Test of the Graduate Record Examinations (GRE). A minimum undergraduate grade point average of 3.0 (on a 4.0 scale) in the biological and physical sciences is required and the combined verbal and quantitative scores on the GRE General Test should be at least 1100. A GRE Subject Test is not required. International students must submit TOEFL scores. Financial assistance is available for qualified applicants through traineeships, fellowships, teaching assistantships and research assistantships.

FOR GRADUATES AND ADVANCED UNDERGRADUATES

TOX 501 General Toxicology. *Preqs.: BCH 451, sr. or grad. standing. 3(3-0) F.* The basis of toxic action at cellular and molecular levels covering the absorption, distribution, elimination and metabolism of toxicants; toxic action (acute toxicity, carcinogenesis, mutagenesis, organ toxicity, etc.); chemical classes of toxicants; and toxicity testing.

TOX 510 Biochemical Toxicology. *Preqs.: Biochemistry, sr. standing. 3(3-0) S.* Emphasis placed on the molecular events that occur during the toxic action of xenobiotics, including penetration phenomena, mechanisms involved in detoxication, and the mechanisms of action at the target site.

TOX 515 Environmental Toxicology. *Preq.: Two years of biology. 3(3-0) F.* The nature, distribution and significance of microchemical contamination evaluated. Emphasis placed on current, relevant problems.

TOX (ST) 563 Statistical Problems in Toxicology. *2(2-0) S. Alt. yrs.* (See statistics.)

TOX 590 Special Problems in Toxicology. *Preq.: Grad. standing. 1-3.*

FOR GRADUATES ONLY

TOX 690 Toxicology Seminar. *Preq.: Grad. standing. 1(1-0) S.*

TOX 699 Research. *Preq.: Grad. standing. Credits Arranged. F,S.* Original research in connection with thesis problem in toxicology.

COURSES FROM ASSOCIATED DEPARTMENTS

BCH 652 Structures and Interactions of Biological Macromolecules

CH 428 Qualitative Organic Chemistry

ENT 622 Insect Toxicology

VMS 531 Mammalian Neuroanatomy

VMS 540 Research Animal Care and Use

VMS 553 Veterinry Immunology

VMS 560 Introductory Pharmacology

VMS 562 Systemic Pharmacology and Toxicology

VMS 563 Systemic Pharmacology and Toxicology Laboratory

VMS 690B Special Topics in Pathology

VMS 696A Seminar in Pharmacology

ZO 614 Advanced Cell Biology

SELECTED COURSES AT UNIVERSITY OF NORTH CAROLINA AT CHAPEL HILL

PHARM 216 Introductory Pharmacology

EPID 162 Epidemiology

SELECTED COURSE AT DUKE UNIVERSITY

PATH 382 Toxicological Pathology

Veterinary Medical Sciences

GRADUATE FACULTY

Professor C. E. Stevens, Coordinator

Professors: W. M. Adams, R. A. Argenzio, A. L. Aronson, H. J. Barnes, P. J. Bentley, H. A. Berkhoff, C. W. Betts, E. B. Breitschwerdt, T. T. Brown Jr., P. B. Carter, L. Coggins, T. M. Curtin, R. C. Dillman, J. P. Fetrow, B. Hammerberg, B. D. Harrington, D. R. Howard, J. N. Kornegay, C. W. McPherson, D. J. Moncol, W. D. Oxender, J. E. Riviere, M. C. Roberts, J. E. Smallwood, J. Stevens, C.-S. Teng, D. E. Thrall, W. Tompkins; *Adjunct Professors:* S. W. Crane, R. R. Maronpot, B. A. Schwetz, F. Welsch; *Professor Emeritus:* E. G.

Batte; *Associate Professors*: K. B. Adler, K. F. Bowman, C. F. Brownie, W. T. Corbett, E. V. De Buysscher, D. J. DeYoung, L. N. Fleisher, R. B. Ford, L. C. Hudson, E. Hunt, M. G. Levy, T. O. Manning, D. J. Meuten, E. J. Noga, N. C. Olson, C. L. Robinette, P. L. Sannes, E. A. Stone, L. P. Tate Jr., S. D. Van Camp, M. D. Whitacre; *Adjunct Associate Professors*: G. A. Boorman, T. E. Eling, M. S. Hand, E. E. McConnell, R. L. Peiffer, C. T. Teng; *Assistant Professors*: G. W. Almond, K. L. Anderson, P. J. Armstrong, S. A. Bai, H. M. Berschneider, B. A. Breuhaus, S. E. Bunch, R. C. Cattle, P. Cowen, J. M. Cullen, M. G. Davidson, W. M. Duckett, M. D. Ficken, K. Flammer, F. J. Fuller, J. E. Gadsby, C. B. Grindem, J. S. Guy, E. M. Hardie, P. W. Hellyer, J. F. Levine, D. H. Ley, M. R. Metcalf, R. E. Meyer, M. P. Nasisse, P. E. Orndorff, R. L. Page, D. C. Richardson, K. A. Spaulding, C. R. Swanson, L. P. Tate Jr., M. B. Tompkins, S. Tonkonogy, C. Uhlinger, S. J. Updike, D. P. Wages, D. Weinstock; *Visiting Assistant Professors*: D. P. Aucoin, B. R. Grubb, L. J. Konde, M. C. McGahan, N. A. Monteiro-Riviere; *Adjunct Assistant Professor*: M. W. Dewhirst; *Electron Microscopy Director*: M. J. Dykstra

ASSOCIATE MEMBERS OF THE COLLEGE

Professor: R. F. Behlow; *Extension Professor*: J. R. Harris

Graduate study under the direction of the veterinary medical faculty may lead to the Master of Science and the Doctor of Philosophy degrees. The veterinary medical faculty is a multidisciplinary group drawn from the departments of the College of Veterinary Medicine: Anatomy, Physiological Sciences and Radiology; Microbiology, Pathology and Parasitology; Companion Animal and Special Species; and Food Animal and Equine Medicine. Students will be associated with members from the above departments and conduct their research in the laboratory of their committee chairman or co-chairman.

The program provides training in basic and applied veterinary medical research to qualified students with a baccalaureate, D.V.M. or equivalent degree. Major areas of concentration include cell biology, morphology, pharmacology, pathology, veterinary microbiology and immunology, and epidemiology and population medicine. Minors may be chosen from a wide range of programs including animal science, biochemistry, genetics, nutrition, poultry science, physiology, statistics, toxicology and zoology.

The College offers a combined DVM/Ph.D. Program for a limited number of students admitted to both the College of Veterinary Medicine professional program and the Graduate School. This program is designed to reduce the time required for completion of both degrees. Those who are interested in this program should contact the Director of Graduate Studies at the time they are seeking admission to the veterinary professional program of the College.

Prerequisites for admission include a strong background in biological science. Verbal and quantitative tests of the Graduate Record Examination are required except for candidates with a DVM degree.

Financial assistance for qualified students in the form of graduate assistantships is available through the College of Veterinary Medicine and participating faculty. Prospective students may obtain further information by writing to one of the graduate faculty listed above or to the Coordinator, Veterinary Medical

Sciences Program, College of Veterinary Medicine, North Carolina State University, 4700 Hillsborough Street, Raleigh, North Carolina, 27606.

SELECTED ADVANCED UNDERGRADUATE COURSE

VMS 490 Special Topics in Veterinary Medicine. 1-6 F,S.

FOR GRADUATES AND ADVANCED UNDERGRADUATES

VMS 530 Veterinary Histology. *Preqs.: BCH 451 and CI. 3(2-4) F. Alt. yrs.* The structure of cells, tissues and organs of domestic animals studied using light microscopy.
Sannes

VMS 531 Mammalian Neuroanatomy. *Preqs.: VMA 811 or 812 or ZO 323 and grad. standing or CI. 3(2-2) F. Alt. yrs.* The course provides detailed information about the structure of the nervous system of nonprimate animals. Emphasis on the dog and cat but other domestic and laboratory mammals studied. Overviews of embryology, neurohistology and experimental techniques included.
Hudson

VMS 532 Electron Microscopy in Veterinary Medicine. *Preq.: CI. 4(2-4) S.* The course provides an introduction to ultramicrotomy, tissue processing for electron microscopy, theory and utilization of the transmission electron microscope and scanning electron microscope, darkroom techniques and an introduction to various specialized techniques for the preparation of samples for veterinary diagnostic and research electron microscopy.
Dykstra

VMS 540 Research Animal Care and Use. *Preq.: ZO 201 or equivalent. 3(2-3) S. Alt. yrs.* The principles of the selection, care and use of animals in laboratory teaching and investigation presented. Topics include the ethics of animal experimentation, selection of animal models, biology and care of laboratory animals, techniques of administration of substances and obtaining of specimens, producing surgical alterations and common laboratory animal health problems.
McCormick, McPherson

VMS 541 Laboratory Animal Diseases. *Preqs.: MB 401, VMS 540, ZO 345 and grad. standing or CI. 3(2-3) S. Alt. yrs.* The diseases of common laboratory animals studied by discussing their etiology, epizootiology, pathogenesis and clinical signs. The diagnosis of laboratory animal diseases by clinical examination of animals and post-mortem evaluation of gross and microscopic pathologic changes within animal tissues emphasized. Procedures for disease prevention, treatment and control also reviewed.
McPherson, Wright

VMS 550 Veterinary Medical Virology I. *Preqs.: BCH 451, MB 401 and grad. standing. 2(2-0) S.* Basic principles of animal virology and the relationship of viruses to diseases in domestic animals discussed.
Fuller

VMS 551 Pathogenic Bacteriology and Mycology. *Preqs.: MB 411, grad. standing and CI. 3(2-2) F.* The lecture course covers the pathogenic bacteria and fungi important in medicine. Lectures supplemented by laboratory exercises that provide students the opportunity to learn basic characteristics of these microorganisms and how they are isolated, cultivated and identified.
Berkhoff, Carter

VMS 552 Diagnostic Bacteriology and Mycology. *Preqs.: Grad. standing, VMM 814 or VMS 551 and CI. 3(1-8) F,S.* Principles of specimen collection, selection and use of media, culture processing and identification of bacteria and fungi important in animal disease are presented.
Berkhoff

VMS 553 Veterinary Immunology. *Preqs.: MB 501C and grad. standing. 2(2-0) S.* Basic and clinical immunology presented. The role of the immune system in disease prevention, inflammation and autoimmune diseases discussed.
Tonkonogy, De Buysscher

VMS 554 Principles of Epidemiology. *Preq.: Grad. standing or CI. 3(2-4) F. Alt. yrs.* Principles of epidemiology related to the investigation of disease involving the agent-host-environment concepts presented. Epidemiological techniques and experimental design stressed. Descriptive, analytical and experimental epidemiology pertinent to disease etiology and prevention are the main focus. Corbett

VMS (MB, PHY, PO) 556 Immunogenetics. *3(2-2) F.* (See poultry science.)

VMS 560 Introductory Pharmacology. *Preqs.: BCH 451, grad. standing or CI. 5(4-1) F.* The action of drugs in animals and man including basic principles of drug disposition and pharmacokinetics discussed. Modification of physiological processes by drugs influencing coordination by the nervous, endocrine and circulatory system described. Bai, Bentley, Fleisher

VMS 561 Instrumentation in Pharmacological Research. *Preqs.: BCH 452B or CH 315 and grad. standing or CI. 2(1-4) F.* The theory and applications of modern scientific instrumentation to the analysis of tissues, body fluids and drugs in pharmacological research described. Appropriate aspects of the pharmacological use of spectroscopy, microscopy, chromatography, electrophoresis, radioisotope usage and centrifugation discussed. Robinette

VMS 562 Systemic Pharmacology and Toxicology. *Preq.: VMS 560 or equivalent. 3(3-0) S. Alt. yrs.* Drug and toxicant action at the organ systems level discussed in terms of underlying physiological mechanisms and responses. Emphasis is placed on the kidney and liver with additional consideration given to the respiratory, reproductive, gastrointestinal, hematologic and immune systems. Methods for assessing function of these systems presented. Riviere

VMS 563 Systemic Pharmacology and Toxicology Laboratory. *Preqs.: VMS 560, VMS 562 and grad. standing. 1(0-4) F. Alt. yrs.* A series of laboratory exercises given which are designed to complement the lecture course in Introductory Pharmacology (VMS 560) and Systemic Pharmacology and Toxicology (VMS 562). Bentley, Riviere, Graduate Staff

VMS 570 Cell Biology. *Preqs.: BCH 451, BS 100, CH 223 or equivalent or CI. 3(3-0) F.* Advanced cell and organelle structure and function, and recent advances in molecular biology. Emphasis on current literature and application of research procedures. Adler

VMS 590 Special Topics in Veterinary Medical Sciences. *Preq.: Sr. or grad. standing. 1-3 F,S,Sum.* A course designed to present new or special subject matter within the scope of pathology, veterinary microbiology, morphology or pharmacology. The studies may include independent investigations, seminars and/or formal lectures. Graduate Staff

FOR GRADUATES ONLY

VMS 631 Applied Veterinary Anatomy I. *Preqs.: DVM or equivalent and CI. 4(2-8) F. Alt. yrs.* This course provides the graduate veterinarian with detailed anatomic information relevant to surgical and medical problems in domestic carnivores. Designed for graduate veterinarians in pursuit of advanced training in the areas of anatomy, physiology, surgery, radiology and pathology. Smallwood

VMS (PHY) 632 Comparative Physiology of the Digestive System. *Preq.: Course in general or comparative physiology; Coreq.: CI. 3(3-0) Every yr.* Discussion of the major functions of vertebrate digestive systems and structural and functional adaptations to diet, environment and other characteristics of the animals. Argenzio

VMS 640 Cellular and Subcellular Pathology. *Preqs.: VMS 630 and CI. 2(2-0) S. Alt. yrs.* Ultrastructural and biochemical changes occurring in cell injury studied by the evaluation and interpretation of electron and scanning photomicrographs. Brown, Graduate Staff

VMS 642 Advanced Systemic Histopathology. *Preq.: Grad. students holding DVM or equivalent degree and CI. 2(1-3) S. Alt. yrs.* Histopathologic changes associated with diseases of various organ systems. The pathogenesis and morphologic changes associated with selected diseases emphasized. Meuten

VMS 643 Toxicologic Pathology I. *Preqs.: Those holding DVM or equivalent degree or CI. 3(2-2) F. Alt. yrs.* A review of the principles and practices of toxicologic pathology and a survey of common spontaneous and chemically induced lesions by organ systems with emphasis on recognition and interpretation. Meuten

VMS 650 Bacterial Pathogenic Mechanisms. *Preqs.: MB 501, VMS 552 or VMM 814. 2(2-0) S. Alt. yrs.* Principles of pathogenesis and host-response in bacterial infections of animals discussed. Berkhoff, Carter

VMS 651 Veterinary Medical Virology II. *Preq.: VMM 824 or VMS 550 or CI. 3(2-4) F. Alt. yrs.* Principles of animal viral pathogenesis and host-response to viral infection presented. The biology of selected viral groups including oncogenic viruses and persistent viruses discussed. Common laboratory techniques used in virology stressed. Coggins, Fuller

VMS (MB) 653 Advanced Immunology. *Preq.: VMS 553 or VMM 815 or MB 551 or equivalent or CI. 3(3-0) F. Alt. yrs.* The ontogeny and phylogeny of self and non-self recognition studied. Emphasis placed on basic mechanisms that evolved during the evolution of the species. Speciality areas such as immunology of reproduction and genetic regulation of the immune response studied. Tonkonogy, DeBuysscher

VMS 654 Epidemiology of Infectious Diseases of International Importance. *Preq.: CI. 3(2-4) F. Alt. yrs.* Infectious diseases and epidemiological principles discussed. Selected enteric, zoonotic, nosocomial diseases of worldwide importance stressed. Population dynamic techniques related to host-vector-agent considered. Corbett

VMS 660 Advanced Pharmacology. *Preqs.: VMS 560 or equivalent and CI. 2(2-0) S. Alt. yrs.* An in-depth study of current topics in pharmacology. Subjects include but not limited to: the actions of drugs on ion permeability, prostaglandins, receptors, pharmacologically active peptides, toxicity of heavy metals and anti-fertility drugs. Bentley

VMS 661 Pharmacokinetics. *Preqs.: VMS 560 or equivalent, working knowledge of calculus and CI. 3(3-0) F. Alt. yrs.* A course on mathematical models to describe the disposition of drugs and toxic chemicals in the animal body. Areas covered include classic compartmental and nonlinear models as well as physiological approaches. The application of these techniques to toxicologic studies discussed. Bai

VMS 690A Special Topics in Veterinary Microbiology. *Preq.: Grad. standing. 1-3 F,S.* Specific topics of study assigned in various laboratories involved in veterinary microbiology investigation. Students conduct in-depth studies of assigned problem areas. Graduate Staff

VMS 690B Special Topics in Pathology. *Preqs.: Those holding DVM degree and CI. 1-4 F,S,Sum.* Students perform necropsies, microscopically evaluate tissue changes and prepare written reports of findings. Students conduct in-depth studies of each assigned case. Brown, Graduate Pathology Staff

VMS 690C Special Topics in Laboratory Pharmacology. *Preqs.: Grad. standing and CI. 1-3 F,S,Sum.* The course involves practical participation in the normal research activities of different laboratories working in pharmacological research. Students pursue a semi-independent project. Bentley

VMS 690D Special Topics in Clinical Pathology. *Preqs.: DMV or equivalent degree and CI. 1(0-4) F,S,Sum.* New, fundamental and in-depth understanding of selected topics in clinical pathology (blood coagulation, acid-base balance, hematology, cytology, and clinical

chemistry). A new topic selected each semester. Students read pertinent current journal articles and references and lead weekly discussion sessions. Clinical application of this information stressed.
Grindem, Stevens

VMS 691 Advanced Topics in Immunology and Biotechnology. *Preqs.: VMS 553, MB 551 or CI. 1(1-0) F,S,Sum.* A study of selected topics of current interest in immunology/biotechnology. A new topic selected each semester to keep the advanced graduate students up to date on the most recent developments in these fields.
Tonkonogy

VMS 694A Seminar in Necropsy Pathology. *Preqs.: Those holding the DVM or equivalent degree and CI. 1(1-0) F,S,Sum.* Description and interpretation of gross changes in tissues from diseased domestic animals. Students attend daily (M-F) 15 to 30 minute review of necropsy lesions presented by a member of the graduate staff.
Brown, Graduate Pathology Staff

VMS 694B Seminar in Surgical Pathology. *Preqs.: Those holding the DVM or equivalent degree and CI. 1(1-0) F,S,Sum.* Description and interpretation of microscopic changes in tissues from diseased domestic and laboratory animals. Students attend and participate in a one-hour weekly seminar where microscopic lesions described, interpreted and discussed.
Brown, Graduate Pathology Staff

VMS 695A Seminar in Veterinary Microbiology. *Preq.: Grad. standing. 1(1-0) F,S.* Presentation of ongoing research and current topics in microbiology.
Graduate Staff

VMS 696A Seminar in Pharmacology. *Preqs.: Grad. standing and CI. 1(1-0) S.* Presentations and discussions of pharmacological topics of current interest and importance are made.
Bentley

VMS 697 Seminar in Cell Biology. *Preqs.: Grad. standing and CI. 1(1-0) F,S.* Presentation and discussions of ongoing research and current topics in cell biology.
Adler

VMS 699 Research in Veterinary Medical Sciences. *Preq.: Grad. standing. 1-3 F,S,Sum.* Original research in connection with thesis or dissertation problems in veterinary medical sciences.
Graduate Staff

Water Resources

(An interdepartmental graduate program)

WATER RESOURCES COMMITTEE

Dr. J. D. Gregory, *Chair*

Dr. J. M. Burkholder (Botany), Dr. M. R. Overcash (Chemical Engineering), Dr. W. S. Galler (Civil Engineering), Dr. T. J. Sheets (Crop Science), Dr. R. B. Palmquist (Economics and Business), Dr. H. H. Neunzig (Entomology), Dr. V. A. Jones (Food Science), Prof. R. R. Wilkinson (Landscape Architecture), Dr. C. W. Welby (Marine, Earth and Atmospheric Sciences), Dr. J. W. Gilliam (Soil Science), Dr. C. B. Smith (Textile Engineering, Chemistry and Science), Dr. T. W. Joyce (Wood and Paper Science), Dr. S. C. Mozley (Zoology)

The graduate minor in water resources is an interdisciplinary, interdepartmental minor that is designed to provide a specialization in water resources for students who are majoring in the many disciplines of natural resources, engi-

neering, technology and social sciences that are related to or involve water management. The ever-increasing demands for good water management in all elements of our society continue the need for well-trained professionals in water resources. Such professionals should have a strong grounding in a major discipline coupled with a broad understanding of and appreciation for the complex physical, biological, and social elements of water resources management. The graduate minor in water resources will expose students to several different courses and faculty members in water resources that are outside his/her major field of study.

A graduate student may enroll in the water resources minor by including it on the plan of graduate work. A graduate faculty member from outside the student's major department or program must be appointed to serve as the minor representative on his/her advisory committee. The minor representative may be a member of the Water Resources Committee or another faculty member from a department represented on the Water Resources Committee who is active in teaching/research related to water resources. The minimum course requirements for a graduate minor in water resources are:

Master's Degree—Three courses (minimum of eight credit hours) from water resources areas outside the student's major field of study approved by the student's minor representative. **Doctor of Philosophy Degree**—Three courses (minimum of eight credit hours) from water resources areas outside the student's major field of study approved by the student's minor representative. These courses shall be in addition to those previously taken at the master's level when that degree included a water resources minor. **Recommended Course**—A course in the legal, institutional, or economic aspects of water resources is highly recommended for each minor program.

A water resources minor will normally be composed of courses from the list below. The student may select one or more courses from several subject areas or concentrate all courses in one area. Other courses that are water resources-oriented may be included when approved by the student's minor representative:

- (1) Other North Carolina State University courses
- (2) Transfer courses from other institutions
- (3) Courses taken through Interinstitutional Registration at Duke University and the University of North Carolina at Chapel Hill.

Additional information on appropriate courses may be obtained from any member of the Water Resources Committee.

Requests for information on water resources-oriented graduate programs should be directed to the departments represented on the Water Resources Committee. For additional information on the water resources minor, contact Dr. James D. Gregory, Chair, Water Resources Committee, Department of Forestry, North Carolina State University, Box 8002, Raleigh, N.C. 27695-8002.

WATER RESOURCES COURSES

Legal, Institutional and Economic Aspects of Water Resources

FOR	472	Renewable Resource Policy and Management
EB	436	Environmental Economics
PA	520	Environmental Policy
EB	515	Environmental and Resource Policy

Planning of Water Resources and Related Systems

CE	504	Water Transportation
CE	575	Civil Engineering Systems
FOR (UNI)	584	The Practice of Environmental Impact Assessment

Municipal and Industrial Water Management

CE	484	Water Supply and Waste Water Systems
CE (BAE, MB)	570	Sanitary Microbiology
CE	571	Theory of Water and Waste Treatment
CE	572	Design of Water and Wastewater Facilities
CE	573	Unit Operations and Processes in Waste Treatment
CE	674	Stream Sanitation
T	401	Environmental Aspects of the Textile Industry
WPS	525	Pollution Abatement in Forest Products Industries

Agricultural and Forest Water Management

BAE	471	Soil and Water Engineering
BAE (CE)	578	Agricultural Waste Management
FOR	401	Forest Hydrology and Watershed Management
SSC	461	Soil Physical Properties and Plant Growth
SSC	511	Soil Physics

Aquatic Biology and Ecology

BO (ZO)	560	Principles of Ecology
BO	574	Phycology
BO	590F	Topical Problems: The Ecology of Freshwater Plants
MEA (ZO)	520	Principles of Biological Oceanography
ZO	441	Biology of Fishes
ZO (FW)	420	Fishery Science
ZO	460	Aquatic Natural History Laboratory
ZO (ENT)	509	Ecology of Stream Invertebrates
ZO	519	Limnology
ZO (FW)	586	Aquaculture I
ZO (FW)	587	Aquaculture I Laboratory
ZO	592	Topical Problems
ZO	593	Aquatic Ecology Seminar

Hydrology and Hydrogeology

BAE (SSC)	671	Theory of Drainage—Saturated Flow
BAE (SSC)	674	Theory of Drainage—Unsaturated Flow
CE	580	Flow in Open Channels
CE	585	Urban Stormwater Management
CE	644	Ground Water Contaminant Transport
FOR	601	Advanced Hydrology
MEA	481	Principles of Geomorphology
MEA	455	Micrometeorology
MEA	555	Meteorology of the Biosphere
MEA	560	Principles of Physical Oceanography
MEA	565	Hydrogeology
MEA	566	Hydrogeology of Groundwater Pollution and Protection
MEA	567	Geochemistry

Wildlife Biology

GRADUATE FACULTY

Professor R. L. Noble, Coordinator

Professors: D. A. Adams, B. J. Copeland, P. D. Doerr, E. C. Franklin, J. M. Miller, K. H. Pollock; *Professor (USDI):* M. T. Huish; *Professor Emeritus:* D. W. Hayne; *Associate Professors:* L. B. Crowder, R. G. Hodson, R. A. Lancia, S. C. Mozley, R. A. Powell, G. J. San Julian, J. R. Walters; *Associate Professor (USDI):* J. W. Fleming; *Assistant Professors:* J. M. Hinshaw, E. J. Jones, T. M. Losordo, J. A. Rice, C. V. Sullivan

The Fisheries and Wildlife Sciences Program is an interschool program jointly administered by the Departments of Forestry and Zoology. Graduate study under direction of the fisheries and wildlife sciences faculty may lead to the Master of Science in Wildlife Biology, Forestry or Zoology and the Master of Wildlife Biology, Master of Life Sciences or Master of Forestry. The Doctor of Philosophy degree may be pursued in either the Departments of Forestry or Zoology with emphasis on fisheries and wildlife sciences. The program emphasizes assessment, biology, ecology and management of fish and wildlife species and their habitat. In addition, work can be undertaken in the Institute of Statistics, home of the Southeastern Cooperative Wildlife and Fisheries Statistics Project.

Research facilities near campus include an aquaculture laboratory, the Biology Field Laboratory consisting of environmental chambers, a 20-acre pond and associated forest, the Harris Lands natural area and the Schenck Forest. Off-campus research is conducted at several of the university farms and forests, at the Pamlico and Tidewater Aquaculture Centers, and at the facilities of state and federal agencies and private organizations throughout the Southeast.

Teaching and research assistantships are available for qualified students through participating departments. Prospective students may obtain further information by writing to Coordinator, Fisheries and Wildlife Sciences Program, Box 7617, North Carolina State University, Raleigh, NC 27695-7617.

SELECTED ADVANCED UNDERGRADUATE COURSES

FW(ZO) 404 Forest Wildlife Management. *Preqs.: BS 100 or equivalent plus 8 hrs. of biological sciences; advanced undergrad. or grad. student. 3(3-0) S.*

FW(ZO) 420 Fishery Science. *Preqs.: ZO 201 or 303, ZO 360. 3(2-2) F.*

FW(FOR) 430 Fisheries and Wildlife Administration. *Preqs.: Political science course and either FW (ZO) 420 or FW (ZO) 353; advanced undergrad. or grad. standing. 3(3-0) S.*

FW(AC) 485 Natural Resources Advocacy. *Preqs.: ENG 333; jr. or sr. level with at least 10 hrs. of biology. 3(2-3) S.*

FOR GRADUATES AND ADVANCED UNDERGRADUATES

FW(ZO) 515 Fish Physiology. *3(2-3) F. Alt. yrs. (See zoology.)*

FW(ZO) 553 Principles of Wildlife Science. 3(2-3) F. (See zoology.)

FW(ZO) 554 Wildlife Field Studies. 3(2-3) S. *Odd yrs.* (See zoology.)

FW(FOR) 585 Advanced Wildlife Habitat Management. 3(2-3) S. *Alt. yrs.* (See forestry.)

FW(ZO) 586 Aquaculture I. 3(3-0) F. *Alt. yrs.* (See zoology.)

FW(ZO) 587 Aquaculture I Laboratory. 1 (0-3) F. *Alt. yrs.* (See zoology.)

FW(FOR) 594 Seminar in Wildlife Management. 1(1-0) S. *Alt. yrs.* (See forestry.)

COURSES FROM ASSOCIATED DEPARTMENTS

FOR 572A,B Forest Management Policies on the Public Lands. 2(2-0) S.

FOR(UNI) 584 The Practice of Environmental Impact Assessment. 4(0-8) F. *Alt. yrs.*

ZO 501 Ornithology. 3(2-3) S.

ZO(ST) 506 Sampling Animal Populations. 3(3-0) F. *Alt. yrs.*

ZO(ENT) 509 Ecology of Stream Invertebrates 4(2-6) S. *Alt. yrs.*

ZO 519 Limnology. 4(3-3) F.

ZO(MEA) 520 Principles of Biological Oceanography. 3(3-0) S.

ZO 542 Herpetology. 3(2-3) S. *Even yrs.*

ZO 544 Mammalogy. 4(3-3) F.

ZO 593 Aquatic Ecology Seminar. 1-3, F,S.

ZO 619 Advanced Limnology. 3(3-0) S. *Alt. yrs.*

ZO 621 Fishery Science. 3(2-3) F. *Alt. yrs.*

ZO(MEA) 624 Ecology of Fishes. 3(3-0) F.

ZO 644 Advanced Topics in the Study of Mammals. 3(2-3) S.

Wood and Paper Science

GRADUATE FACULTY

Professor R. J. Thomas, Head

Professor R. G. Pearson, Graduate Administrator

Professors: H.-m. Chang, E. B. Cowling, I. S. Goldstein, J. S. Gratzl, C. A. Hart, T. W. Joyce, M. W. Kelly, M. P. Levi, H. G. Olf, E. A. Wheeler; *Adjunct Professors:* L. L. Edwards, T. K. Kirk, R. P. Singh; *Professors Emeriti:* A. C. Barefoot Jr., E. L. Ellwood; *Associate Professors:* E. L. Deal Jr., J. A. Heitmann Jr., H. Jameel; *Adjunct Associate Professor:* R. B. Phillips; *Associate Professor Emeritus:* C. G. Landes; *Assistant Professor:* J. Denig; *Research Associate:* C. L. Chen

Graduate study programs leading to the Master of Science and the Doctor of Philosophy degrees are offered for students in a wide variety of areas in the field of wood and paper science. The Master of Wood and Paper Science is available for students who do not wish to emphasize research in their graduate study programs.

Because the field of wood and paper science is a derived science, considerable emphasis is placed upon developing a strong minor in the graduate program in any one or more of the supporting disciplines such as organic chemistry, polymer

chemistry, chemical engineering, mathematics, statistics, biology, engineering mechanics, mechanical engineering, physics, economics or business administration.

Areas of study and research in pulp and paper science and technology cover wood and fiber chemistry, lignin and carbohydrate chemistry, pulping chemistry, pollution abatement processes, fiber and paper properties and paper coatings and additives. In wood science and technology, study and research areas include wood physics (especially wood liquid relations), wood chemistry, wood biology, wood mechanics and engineering, manufacturing processes, wood-based industry economics and marketing.

Modern facilities equipped to conduct education and research in all forms of wood and fiber processing are available. Included are specialized laboratories for the study of wood physics, wood anatomy, wood processing, wood engineering, wood chemistry, pulping, papermaking, paper testing and paper coating. Equipment available includes optical and electron microscopes, a range of spectrometers, gas, liquid and ion chromatographs; ultracentrifuge, membrane osmometers, electron spin resonance, nuclear magnetic resonance apparatus weatherometer, a range of lumber and paper testing machines, molecular filtration equipment and excellent computer and computer graphics facilities.

The prerequisite for graduate study in the department is an undergraduate degree in wood science, pulp and paper science or in related disciplines such as any of a number of branches of science or engineering.

SELECTED ADVANCED UNDERGRADUATE COURSES

WPS 403 Paper Process Analysis. *Preqs.: WPS 321, 322, 3(1-6) S.*

WPS 410 Pulp and Paper Systems Analysis and Control. *Preq.: WPS 322 or WPS 360, 3(3-0) F.*

WPS 413 Paper Properties and Additives. *Preq.: Sr. standing, 3(1-6) F.*

WPS 415 Project Management and Analysis I. *Preq.: Sr. standing in pulp and paper science and technology, 2(2-0) F.*

WPS 416 Project Management and Analysis II. *Preq.: WPS 415, 2(2-0) S.*

WPS (FOR) 434 Quantitative Methods of Decision Making for Forest Products. *Preqs.: MA 113 and 114 and WPS (FOR) 273, 3(3-0) S.*

WPS 441 Introduction to Wood Mechanics. *Preqs.: MA 212, PY 221 or 211, 3(3-0) F.*

WPS 442 Wood Mechanics and Structural Design. *Preq.: CE 211 or WPS 441, 3(2-3) S.*

WPS 471 Pulping Process Analysis. *Preqs.: WPS 321, WPS 322, 3(1-6) F.*

FOR GRADUATES AND ADVANCED UNDERGRADUATES

WPS 513 Tropical Woods. *Preq.: WPS 202, 2(1-3) F. Alt. yrs. Structure, identification, properties, characteristics and use of tropical woods, especially those used in plywood and furniture.*
Wheeler

WPS 515 Surface and Colloid Chemistry of Papermaking. *Preq.: CH 331 or CH 431, 3(3-0) S. The fundamental principles of surface and colloid chemistry important in paper-*

making and their application to optimizing wet-end processes. The electrokinetic basis of flocculation, retention and other wet-end phenomena and the science of wet-end additives.
Olf

WPS 521 Chemistry of Wood Polysaccharides. *Preqs.: CH 223 and WPS 332 or BCH 451. 3(3-0) F. Alt. yrs.* Fundamental chemistry and physical chemistry of monosaccharides and polysaccharides with emphasis on hemicellulose and cellulose. Topics include construction and configuration, stereochemistry, solution properties, molecular weight determination and reactivity.
Chang, Gratzl

WPS 522 Chemistry of Lignin and Extractives. *Preqs.: CH 223 and WPS 332 or BCH 451. 3(3-0) S. Alt. yrs.* A study of the biosynthetic pathways, structure and reactivity of lignin and wood extractives with emphasis on topics important to pulping and conversion to useful by-products.
Chang, Gratzl

WPS 525 Pollution Abatement in Forest Products Industries. *Preq.: Grad. or advanced undergrad. standing in science or engineering curricula. 3(3-0) S.* Pollution sources, in-plant control and treatment of water and air pollution in forest products with concentration on the pulp and paper industry.
Joyce

WPS 533 Advanced Wood Anatomy. *Preq.: WPS 202 or CI. 3(1-6) S. Alt. yrs.* Fundamental wood anatomy and cell wall ultrastructure. Laboratory techniques for light and electron microscopic studies of wood.
Wheeler

WPS 540 Wood Composites. *Preqs.: WPS 441; grad. or advanced undergrad. standing. 3(3-0) S. Alt. yrs.* This course designed to acquaint advanced undergraduate and graduate students with the rapidly expanding field of wood composites. Production processes for particleboard, plywood, hardboard, fiberboard, and other wood composites presented. Elastic theory for the stiffness, strength, and buckling resistance of composites developed. Test procedures for determining mechanical properties and design procedures for glued laminated members, panel products, and built-up members, including I- and box-beams, stressed-skin panels and sandwich panels, outlined.
Kelly, Pearson

WPS 560 Advanced Pulp and Paper Process Analysis. *Preqs.: WPS 321 and 322. 3(3-0) S.* Design and analysis of pulp and paper mill processes; process control applications in pulping, chemical recovery, bleaching and papermaking; principles of pulp mill chemical and energy recovery; and new alkaline pulping recovery technology.
Kirkman

WPS 591 Wood and Paper Science Problems. *Preq.: Sr. or grad. standing. Credits Arranged.* Assigned or selected problems in the field of silviculture, logging, lumber manufacturing, pulp technology or forest management.
Graduate Staff

WPS 599 Methods of Research in Wood and Paper Science. *Preq.: Advanced undergrad. or grad. standing. Credits Arranged.* Research procedures, problem outlines, presentation of results; consideration of selected studies by forest research organizations; sample plot techniques.
Graduate Staff

FOR GRADUATES ONLY

WPS 604 Timber Physics. *Preqs.: MA 212, PY 221, WPS 202. 3(3-0) F. Alt. yrs.* Density, specific gravity and moisture content variation affecting physical properties; physics of drying at high and low temperatures; thermal, sound, light and electrical properties of wood.
Hart

WPS 691 Graduate Seminar. *Preq.: Grad. standing. 1(1-0) F,S.* Presentation and discussion of progress reports on research, special problems and outstanding publications.
Graduate Staff

WPS 693 Advanced Wood and Paper Science Problems. *Preq.: Grad. standing. Credits Arranged.* F, S. Selected problems in the field of wood and paper science.

Graduate Staff

WPS 699 Problems and Research. *Preq.: Grad. standing. Credits Arranged.* Specific problems that will furnish material for a thesis.

Graduate Staff

Zoology

GRADUATE FACULTY

Professor J. G. Vandenberg, Head

Professor D. E. Smith, Graduate Administrator

Professors: G. T. Barthalmus, P. C. Bradbury, B. J. Copeland, P. D. Doerr, W. C. Grant, C. F. Lytle, G. C. Miller, J. M. Miller, R. L. Noble, K. H. Pollock, L. A. Real, J. F. Roberts, D. E. Smith, H. A. Underwood Jr., T. G. Wolcott; *Professor (USDI):* M. T. Huish; *Adjunct Professors:* F. A. Cross, J. B. Funderburg, J. D. Hair, D. E. Hoss, G. R. Huntsman; *Professors Emeriti:* D. E. Davis, W. W. Hassler, T. L. Quay; *Associate Professors:* B. L. Black, L. B. Crowder, M. N. Feaver, R. M. Grossfeld, R. G. Hodson, R. A. Lancia, S. C. Mozley, R. A. Powell, G. J. San Julian, J. R. Walters; *Associate Professor (USDI):* W. J. Fleming; *Adjunct Associate Professors:* C. S. Manooch III, D. S. Peters, L. W. Reiter; *Assistant Professors:* J. M. Hinshaw, T. M. Losordo, D. M. Miller, J. A. Rice, C. V. Sullivan; *Adjunct Assistant Professor:* D. R. Colby

The Department of Zoology offers the Master of Life Science, Master of Science and Doctor of Philosophy degrees. Areas of concentration in the department include: cellular biology and physiology, ecology and behavior, and fisheries and wildlife biology. Within these areas students can specialize in such topics as: developmental biology at the cellular or gene level, cell membrane transport systems, protozoology, parasitology, reproductive physiology, biorhythms, theoretical or applied studies in ecology, wildlife management, aquaculture, and many others. Graduate students in the department may pursue the Master of Wildlife Biology, Master of Science in Wildlife Biology or Master of Science in Ecology.

Excellent research facilities for cellular and organismic work are available in Gardner Hall. Field work can be conducted at near-by research stations and at various state and federal laboratories associated with the department.

Applicants should have a strong background in the biological sciences. Stipends are available for qualified individuals. Application at least six months before the anticipated enrollment date is encouraged.

SELECTED ADVANCED UNDERGRADUATE COURSES

ZO 410 Introduction to Animal Behavior. *Preqs.: BS 100 and either ZO 201 or ZO 303.* 3(3-0) F.

ZO (BO) 414 Cell Biology. *Preqs.: CH 223, PY 212, ZO 201 or ZO 303.* 3(3-0) S.

ZO (FW) 420 Fishery Science. *Preqs.: ZO 201 or ZO 303; ZO (BO) 360. 3(2-2) F.*

ZO 421 Vertebrate Physiology. *Preqs.: CH 223, PY 212, ZO 201 or ZO 303. 3(3-0) F,S,Sum.*

ZO (ENT) 425 General Entomology. *Preq.: ZO 201 or equivalent. 3(2-3) F,Sum.*

ZO 441 Biology of Fishes. *Preqs.: BO (ZO) 360. 3(3-0) F.*

ZO 442 Biology of Fishes Laboratory. *Preq.: BO (ZO) 360; Coreqs.: ZO 441. 1(0-3) F.*

FOR GRADUATES AND ADVANCED UNDERGRADUATES

ZO 501 Ornithology. *Preqs.: ZO 201 or 303; BO(ZO) 360. 3(2-3) S.* The biology of birds, including evolution, functional morphology, physiology, ecology and behavior. Field and museum laboratories emphasize particular aspects of morphology, ecology and behavior, as well as taxonomy and identification. One coastal weekend field trip required. Walters

ZO (PHY) 503 General Physiology I. *3(3-0) F.* (See physiology.)

ZO (PHY) 504 General Physiology II. *3(3-0) S.* (See physiology.)

ZO (ST) 506 Sampling Animal Populations. *3(3-0) F. Alt. yrs.* (See statistics.)

ZO (ENT) 509 Ecology of Stream Invertebrates. *Preqs.: ZO 201 or 302, BO (ZO) 360 or equivalent. 4(2-6) S. Odd yrs.* Introduction to stream ecology and analysis of animal communities. Lectures cover community structure and function, life histories of dominant animals, sampling design and techniques and responses to pollution. Laboratory exercises include field collections, identification of animals and quantitative research techniques. A personal collection of animals and a weekend field trip to mountain streams required.

Mozley

ZO 512 Animal Symbiosis. *Preq.: 12 hrs. of biology and ZO. 3(3-0) S. Odd yrs.* Symbiotic associations of animals including mutualism, commensalism and parasitism. The morphological, physiological, behavioral and ecological adaptations of symbionts and the complex interactions between partner species.

Lytle, G. Miller

ZO (PHY) 513 Comparative Physiology. *Preq.: ZO 421 or CI. 3(3-0) S.* A comparative study of the organ systems of vertebrates and the physiological processes involved in maintaining the homeostatic state. The various compensatory mechanisms employed during environmental stress are included.

Underwood

ZO (FW) 515 Fish Physiology. *Preqs. or coreqs.: GN 411, ZO 420, 421, 441. 3(2-3) F. Even yrs.* The biology of fishes: physiology, anatomy, endocrinology, behavior and genetics. This course designed especially for graduate students in fisheries. Several trips to research laboratories taken.

Sullivan

ZO 517 Population Ecology. *Preqs.: ZO (BO) 360 and ST 511 or equivalent. 3(3-0) F.* The dynamics of natural populations. Current work, theories and problems dealing with population growth, fluctuation, limitation and patterns of dispersion, species interactions, community structure and ecological genetics.

Real

ZO 519 Limnology. *Preqs.: Grad. standing and CI. Credit in both ZO 419 and ZO 519 is not allowed. 4(3-3) F.* Structure and function of lakes and ponds, including physical, chemical and biological controls of productivity and species composition of aquatic plants and animals and effects of pollution on water quality. One local weekend field trip required.

Mozley

ZO (MEA) 520 Principles of Biological Oceanography. *3(3-0) S.* (See marine, earth and atmospheric sciences.)

ZO (PO) 524 Comparative Endocrinology. 4(3-3) S. (See poultry science.)

ZO (MEA) 534 Marine Benthic Ecology. 3(3-0) S. *Alt. yrs.* (See marine, earth and atmospheric sciences.)

ZO (GN) 540 Evolution. 3(3-0) F. (See genetics.)

ZO 542 Herpetology. *Preqs.: ZO 323 or 303, ZO 421. 3(2-3) S. Even yrs.* The biology of the amphibians and reptiles: systematics, life history, anatomy, behavior, physiology and ecology. Graduate Staff

ZO 544 Mammalogy. *Preq.: ZO 323 or ZO 303. 4(3-3) F.* The biology of mammals: evolution, functional morphology, reproduction, behavior, ecology, population biology, classification and identification. One weekend field trip planned. Powell

ZO (FW) 553 Principles of Wildlife Science. *Preq.: ZO (BO) 360. 3(2-3) F.* The principles of wildlife management and their application studied in the laboratory and in the field. Doerr

ZO (FW) 554 Wildlife Field Studies. *Preqs.: ZO 553, ST 311; CI. 3(2-3) S. Odd yrs.* Field application of methods for studying vertebrate wildlife populations; sampling methods, data gathering, analysis and interpretation of results practiced. Participation in field laboratories and one or two weekend field trips required. Doerr

ZO (MB) 555 Protozoology. *Preq.: CI. 4(2-6) S. Odd yrs.* The biology of the Protozoa: lectures include morphology, physiology, ecology, genetics, reproduction, evolution, systematics and life-cycles of both free-living and parasitic taxa; laboratory will stress recognition of selected forms and demonstrate techniques used to prepare specimens for microscopic examination. Bradbury

ZO (BO) 560 Principles of Ecology. *Preq.: Three semesters of college-level biology courses. 4(3-3) F.* A consideration of the principles of ecology at the graduate level. Each of the major subject areas of ecology is developed in sufficient depth to provide a factual and philosophical framework for the understanding of ecology. Graduate Staff

ZO 581 Helminthology. *Preqs.: ZO 323 or 303, ZO 315 or equivalent. 4(2-4) F. Odd yrs.* The study of the morphology, biology and control of parasitic helminths. G. Miller

ZO (ENT) 582 Medical and Veterinary Entomology. 3(2-3) S. (See entomology.)

ZO (FW) 586 Aquaculture I. *Preqs.: ZO (BO) 360, sr. or grad. standing. 3(3-0) F. Even yrs.* The biological and general principles of aquaculture. Lectures emphasize the present status of aquaculture, species involved, techniques employed, and problems encountered. Recent advances in research and development discussed and areas of future research and development identified. Graduate Staff

ZO (FW) 587 Aquaculture I Laboratory. *Preqs.: ZO (BO) 360, sr. or grad. standing; Coreq.: ZO 586. 1(0-3) F. Even yrs.* Methods and techniques of cultivating aquatic organisms. Field trips and reports on local hatcheries and facilities required. (Three to four overnight field trips taken on week days to coastal areas, state hatcheries, and private hatcheries; students are responsible for shared room costs and their meals. Four field trips also taken on laboratory day within driving range of Raleigh.) Graduate Staff

ZO 590 Special Studies. *Preqs.: Twelve hours ZO, CI. Credits Arranged. F,S.* A directed individual investigation of a particular problem in zoology, accompanied by a review of the pertinent literature. A maximum of three hours allowed toward the master's degree. Graduate Staff

ZO 592 Topical Problems. 2*Preq.: CI. 1-3 F,S.* Organized, formal lectures and discussion of a special topic. Graduate Staff

ZO 593 Aquatic Ecology Seminar. *Preqs.: Grad., PBS or sr. standing; one course in aquatic, marine or fisheries areas. 1-3 F.S.* Presentations and discussions of recent research and topical issues in aquatic and marine sciences. Each student enrolled for credit must make at least one presentation. Mozley

ZO (PHY) 595 Seminar in Biology of Reproduction. *Preq.: ZO 421. 2(2-0) F. Even yrs.* Current topics in animal reproduction presented by reproductive physiologists from various Research Triangle institutions. Student presentations of research projects or library projects in the area of animal reproduction. Smith, Gadsby

FOR GRADUATES ONLY

ZO 614 Advanced Cell Biology. *Preq.: ZO (BO) 414 or equivalent. 3(3-0) S. Even yrs.* A study of the current problems of cell biology including the problems of the molecular organization and functions of membrane systems, subcellular organelles and specialized cells. Roberts, Smith

ZO 618 Community Ecology. *Preqs.: BO (ZO) 360, BO (ZO) 560 or equivalent; BO (ZO) 365 or equivalent. 3(3-0) S. Odd yrs.* Animal community structure and function. Effects of competition, predation, coevolution and disturbance on community composition. Ecological and evolutionary controversies emphasized from empirical and theoretical approaches. Graduate Staff

ZO 619 Advanced Limnology. *Preq.: ZO 419. 3(3-0) S. Even yrs.* Recent topics in limnological research. Lectures and discussion draw from journal articles on physical, chemical and biological aspects, including nutrient control of productivity, predator control of community structure and determinants of water quality. A research paper or project required. Mozley

ZO 621 Fishery Science. *Preqs.: ST 511, ZO 420, a course in calculus. 3(2-3) F. Even yrs.* An analysis of fishery research methods. Population enumeration and dynamics. The relationship between fluctuations in natural populations and environmental factors. Graduate Staff

ZO (MEA) 623 Advances in Marine Community Ecology. *3(3-0) S. Alt. yrs.* (See marine, earth and atmospheric sciences.)

ZO (MEA) 624 Ecology of Fishes. *3(3-0) F.* (See marine, earth and atmospheric sciences.)

ZO 644 Advanced Topics in the Study of Mammals. *Preq.: ZO 54. 3(2-3) S. Even yrs.* Current topics in the study of mammals with concentration each year on a different topic, such as community ecology, population biology, evolution or functional morphology. Student research projects required. Powell

ZO (BO) 660 Advanced Topics in Ecology I. *3(3-0) S.* (See botany.)

ZO 690 Seminar. *1(1-0) F,S.* The presentation and defense of original research and current literature. Graduate Staff

ZO 691 Topics in Animal Behavior. *Preq.: Grad. standing. 3(3-0) F. Even yrs.* Intensive examination of selected aspects of animal behavior and their relationship to physiology, ecology and other biological fields. May be repeated for credit when topic changes. Walters

ZO 692 Seminar in Evolutionary Biology. *Preq.: Grad. standing. 1-3 F.* Seminar exploring current concepts and issues in evolutionary aspects of animal behavior, ecology and population biology. Topic varies, may be repeated for credit when topic changes.

Format may be reading and discussing important new books, current journal articles or classic papers. Intended primarily as forum for interaction of students in this area of zoology but open to others.

Graduate Staff

ZO 699 Research in Zoology. *Preqs.: Twelve semester credits in ZO and CI. Credits Arranged. F,S.*

Graduate Staff

GRADUATE FACULTY*

NORTH CAROLINA STATE UNIVERSITY

- Abbate, Angelo Rudy*, Associate Professor of Landscape Architecture. M.L.A., University of Pennsylvania.
- Abbott, George F.*, Visiting Lecturer in Electrical and Computer Engineering. B.S., Polytechnic Institute of Brooklyn.
- Abrams, Charlie Frank, Jr.*, Professor of Biological and Agricultural Engineering. Ph.D., North Carolina State University.
- Adams, David Arthur*, Professor of Forestry and University Studies. Ph.D., North Carolina State University.
- Adams, William M.*, Professor of Food Animal and Equine Medicine; Associate Dean of Veterinary Medicine and Director of Veterinary Medical Services. V.M.D., University of Pennsylvania.
- Adler, Kenneth B.*, Associate Professor of Anatomy, Physiological Sciences and Radiology. Ph.D., University of Vermont.
- Afify, Elsayed M.*, Professor of Mechanical and Aerospace Engineering. Ph.D., University of Michigan.
- Agrawal, Dharma Prakash*, Professor of Electrical and Computer Engineering. Ph.D., Federal Institute of Technology, Lausanne, Switzerland.
- Agris, Paul F.*, Professor of Biochemistry and Head of the Department. Ph.D., Massachusetts Institute of Technology.
- Ahmad, Shuaib Haroon*, Associate Professor of Civil Engineering. Ph.D., University of Illinois.
- Aldrich, David W.*, Assistant Professor of Industrial Engineering. Ph.D., Purdue University.
- Alegre, Julio Cesar*, Visiting Assistant Professor of Soil Science. Ph.D., North Carolina State University.
- Alexander, Samuel Thomas*, Associate Professor of Electrical and Computer Engineering. Ph.D., North Carolina State University.
- Alexander, Winser E.*, Professor of Electrical and Computer Engineering and Graduate Administrator. Ph.D., University of New Mexico.
- Allen, Howard Lee, Jr.*, Associate Professor of Forestry and Soil Science; Director of the Forest Fertilization Cooperative. Ph.D., North Carolina State University.
- Allen, Jonathan C.*, Assistant Professor of Food Science. Ph.D., University of Georgia.
- Allen, Steven G.*, Professor of Economics and Business. Ph.D., Harvard University.
- Almond, Glen W.*, Assistant Professor of Food Animal and Equine Medicine. Ph.D., North Carolina State University.
- Altman, Richard S.*, Lecturer in Design. M. Arch., Washington University.
- Alvarez, Raul Eduardo*, Professor Emeritus of Industrial Engineering. M.S., North Carolina State University.
- Ambrose, John Thomas*, Professor of Entomology. Ph.D., Cornell University.
- Amein, Michael*, Professor Emeritus of Civil Engineering. Ph.D., Cornell University.
- Amerson, Henry Van*, Associate Professor of Botany and Forestry. Ph.D., North Carolina State University.
- Amoozegar, Aziz*, Associate Professor of Soil Science. Ph.D., University of Arizona.
- Anderson, Charles Edward*, Professor of Marine, Earth and Atmospheric Sciences. Ph.D., Massachusetts Institute of Technology.
- Anderson, Charles Eugene*, Professor of Botany. Ph.D., Purdue University.
- Anderson, Clifton A.*, Professor Emeritus of Industrial Engineering. Ph.D., Ohio State University.
- Anderson, James Michael*, Associate Professor (USDA) of Botany and Crop Science. Ph.D., Purdue University.
- Anderson, John R., Jr.*, Associate Professor of Crop Science. Ph.D., University of Illinois.
- Anderson, Kevin Lindsay*, Associate Professor of Food Animal and Equine Medicine. Ph.D., University of Illinois.
- Anderson, Marshall W.*, Adjunct Professor of Biometrics. Ph.D., University of Tennessee.
- Anderson, Norman Dean*, Professor of Mathematics and Science Education. Ph.D., Ohio State University.
- Anderson, Ronald F.*, Adjunct Assistant Professor of Counselor Education. Ph.D., University of Florida.
- Anderson, Ruth D.*, Associate Professor of Speech-Communications. Ph.D., University of Oregon.
- Andrews, Grover J.*, Visiting Associate Professor of Adult and Community College Education and Associate Vice Chancellor for Extension and Public Service. Ed.D., North Carolina State University.
- Andrews, Matthew Tucker*, Assistant Professor of Genetics. Ph.D., Wayne State University.
- Aneja, Viney P.*, Visiting Associate Professor of Marine, Earth and Atmospheric Sciences. Ph.D., North Carolina State University.
- Antin, Jonathan Frank*, Assistant Professor of Industrial Engineering. Ph.D., Virginia Polytechnic Institute and State University.
- Antonelli, Douglas C.*, Adjunct Associate Professor of Industrial Engineering. Ph.D., North Carolina State University.
- Antony, Louise M.*, Assistant Professor of Philosophy and Religion. Ph.D., Harvard University.
- Apperson, Charles Smith*, Professor of Entomology. Ph.D., University of California at Riverside.
- Apple, Jay Lawrence*, Professor of Genetics and Plant Pathology; Coordinator of International Programs. Ph.D., North Carolina State University.
- Archie, Joseph Patrick, Jr.*, Adjunct Associate Professor of Mechanical and Aerospace Engineering. Ph.D., North Carolina State University.
- Ardalan, Susan H.*, Assistant Professor of Electrical and Computer Engineering. Ph.D., North Carolina State University.
- Arends, James Jay*, Associate Professor of Entomology and Microbiology, Pathology and Parasitology. Ph.D., Oklahoma State University.
- Argenzio, Robert Alan*, Professor of Anatomy, Physiological Sciences and Radiology. Ph.D., Cornell University.
- Armstrong, Frank Bradley*, University Professor of Biochemistry, Genetics and Microbiology. Ph.D., University of California at Berkeley.
- Armstrong, Jeffrey D.*, Assistant Professor of Animal Science. Ph.D., North Carolina State University.

*Membership in the Graduate Faculty may be in either of two categories: (1) full status or (2) associate status. Full status permits a faculty member to engage in any and all phases of the graduate programs of the University. Associate members may teach courses at the graduate level and serve as chair of master's advisory committees.

- Armstrong, Pamela Jane*, Assistant Professor of Companion Animal and Special Species Medicine. D.V.M., Ontario Veterinary College, Guelph, Ontario, Canada.
- Arnold, John F.*, Associate Professor of Curriculum and Instruction. Ph.D., University of Connecticut.
- Aronson, Arthur L.*, Professor of Anatomy, Physiological Sciences and Radiology and Head of the Department. Ph.D., University of Minnesota.
- Arya, Satya Pal Singh*, Professor of Marine, Earth and Atmospheric Sciences. Ph.D., Colorado State University.
- Atchley, William R.*, Professor of Genetics and Statistics; Head of the Department of Genetics. Ph.D., University of Kansas.
- Ater, Steven K.*, Assistant Professor of Product/Visual Design. M.F.A., University of Illinois.
- Atkinson, Maxine P.*, Associate Professor of Sociology and Anthropology. Ph.D., Washington State University.
- Aubrecht, Lynn G.*, Visiting Assistant Professor of Curriculum and Instruction. Ph.D., Ohio State University.
- Auciello, Orlando Hector*, Visiting Associate Professor of Nuclear Engineering. Ph.D., National University of Cuyo, Bariloche, Argentina.
- Aucoin, David P.*, Visiting Assistant Professor of Anatomy, Physiological Sciences and Radiology. D.V.M., Michigan State University.
- Aurand, Leonard William*, Professor Emeritus of Food Science. Ph.D., Pennsylvania State University.
- Austin, David F.*, Assistant Professor of Philosophy and Religion. Ph.D., University of Massachusetts.
- Austin, William Wyatt, Jr.*, Professor Emeritus of Materials Science and Engineering. Ph.D., Vanderbilt University.
- Averre, Charles Wilson, III*, Professor of Plant Pathology. Ph.D., Purdue University.
- Azell, Richard Charles*, Professor of Entomology. Ph.D., Cornell University.
- Aycock, Robert*, Professor Emeritus of Plant Pathology. Ph.D., North Carolina State University.
- Ayoub, Mahmoud Amin*, Professor of Industrial Engineering. Ph.D., Texas Technological University.
- Babcock, Bruce*, Assistant Professor of Economics and Business. Ph.D., University of California at Berkeley.
- Babcock, Willard Farrington*, Professor Emeritus of Civil Engineering. S.M., Massachusetts Institute of Technology.
- Bacheler, Jack S.*, Professor of Entomology. Ph.D., University of Florida.
- Bachmann, Klaus Jurgen*, Professor of Materials Science and Engineering. Ph.D., Freie Universitat, Berlin, West Germany.
- Bahler, Dennis R.*, Assistant Professor of Computer Science. Ph.D., University of Virginia.
- Bai, Stephen A.*, Assistant Professor of Anatomy, Physiological Sciences and Radiology. Ph.D., George Washington University.
- Bailey, Jack Eugene*, Associate Professor of Plant Pathology. Ph.D., Michigan State University.
- Bailey, John Albert*, Professor of Mechanical and Aerospace Engineering and Head of the Department. Ph.D., University College of Swansea.
- Baines, Barbara Joan*, Professor of English. Ph.D., Ohio University.
- Baird, Jack Vernon*, Extension Professor of Soil Science and Specialist-in-Charge. Ph.D., Washington State University.
- Baker, James Robert*, Professor of Entomology. Ph.D., University of Kansas.
- Baker-Ward, Lynne*, Assistant Professor of Psychology. Ph.D., University of North Carolina at Chapel Hill.
- Baliga, E. Jayant*, Professor of Electrical and Computer Engineering. Ph.D., Rensselaer Polytechnic Institute.
- Balik, Charles Maurice*, Assistant Professor of Chemical Engineering and Materials Science and Engineering. Ph.D., Case Western Reserve University.
- Ball, David Stafford*, Associate Professor of Economics and Business. Ph.D., University of North Carolina at Chapel Hill.
- Ball, Hershell Ray, Jr.*, Professor of Food Science and Poultry Science. Ph.D., University of Missouri.
- Ballenger, William L.*, Lecturer in Educational Leadership and Program Evaluation. Ph.D., North Carolina State University.
- Ballinger, Walter Elmer*, Professor Emeritus of Horticultural Science. Ph.D., Michigan State University.
- Ballington, James Ralph, Jr.*, Professor of Horticultural Science. Ph.D., North Carolina State University.
- Bandy, Dale Eugene*, Visiting Professor of Soil Science. Ph.D., Cornell University.
- Banker, James Roderick*, Professor of History. Ph.D., University of Rochester.
- Banks-Lee, Pamela*, Assistant Professor of Textile Engineering, Chemistry and Science. Ph.D., North Carolina State University.
- Barclay, William John*, Professor Emeritus of Electrical and Computer Engineering. Ph.D., Stanford University.
- Barefoot, Aldos Cortez, Jr.*, Professor Emeritus of University Studies. D.F., Duke University.
- Barker, James Cathey*, Extension Professor of Biological and Agricultural Engineering. Ph.D., University of Tennessee.
- Barker, Kenneth Reece*, Professor of Plant Pathology. Ph.D., University of Wisconsin.
- Barker, Roger Lee*, Professor of Textile Engineering, Chemistry and Science. Ph.D., Clemson University.
- Barkley, Key Lee*, Professor Emeritus of Psychology. Ph.D., University of North Carolina at Chapel Hill.
- Barnes, Donald Warren, Jr.*, Associate Professor Emeritus of Architecture. Ph.D., Texas A&M University.
- Barnes, Harold John*, Professor of Food Animal and Equine Medicine. Ph.D., Ahmadu Bello University, Zaira, Nigeria.
- Barnhardt, Robert Alexander*, Professor of Textile and Apparel Management and Dean of the College of Textiles. Ed.D., University of Virginia.
- Barnwell, Richard Walker*, Adjunct Associate Professor of Mechanical and Aerospace Engineering. Ph.D., Virginia Polytechnic Institute and State University.
- Barraz, Gerald W.*, Associate Professor of English. M.A., University of North Carolina at Chapel Hill.
- Barriek, Elliott Ray*, Professor Emeritus of Animal Science. Ph.D., Purdue University.
- Bartholmas, George Timothy*, Professor of Zoology. Ph.D., Pennsylvania State University.
- Bartholomew, William Victor*, Professor Emeritus of Soil Science. Ph.D., Iowa State University.
- Bartley, Jon W.*, Associate Professor of Economics and Business. Ph.D., University of North Carolina at Chapel Hill.
- Bassett, John E.*, Professor of English and Head of the Department. Ph.D., University of Rochester.
- Batchelor, Peter*, Professor of Architecture. M.C.P., University of Pennsylvania.
- Bateman, Durward F.*, Professor of Plant Pathology and Dean of the College of Agriculture and Life Sciences. Ph.D., Cornell University.
- Batra, Subhash K.*, Professor of Textile and Apparel Management and Textile Engineering, Chemistry and Science; Associate Head of the Department of Textile and Apparel Management. Ph.D., Rensselaer Polytechnic Institute.
- Batte, Edward Guy*, Professor Emeritus of Microbiology, Pathology and Parasitology. D.V.M., Texas A&M University.

- Baughman, Gerald Robert*, Associate Professor of Biological and Agricultural Engineering. Ph.D., Ohio State University.
- Baumer, David L.*, Associate Professor of Economics and Business. Ph.D., University of Virginia.
- Beagle-Ristaino, Jean*, Assistant Professor of Plant Pathology. Ph.D., University of California at Davis.
- Beatty, Kenneth Orion, Jr.*, Professor Emeritus of Chemical Engineering. Ph.D., University of Michigan.
- Beck, Keith R.*, Professor of Textile Engineering, Chemistry and Science. Ph.D., Purdue University.
- Beckmann, Robert Lee, Jr.*, Associate Professor of Botany. Ph.D., Vanderbilt University.
- Bedair, Salah Mohamed*, Professor of Electrical and Computer Engineering. Ph.D., University of California at Berkeley.
- Beeler, Joe Robert, Jr.*, Professor of Materials Science and Engineering. Ph.D., Kansas State University.
- Beers, Burton Floyd*, Professor of History. Ph.D., Duke University.
- Beezer, Bruce Gerald*, Professor of Educational Leadership and Program Evaluation. Ed.D., University of Arizona.
- Beezley, William H.*, Professor of History. Ph.D., University of Nebraska.
- Behlow, Robert Frank*, Professor Emeritus of Animal Science. D.V.M., Ohio State University.
- Behnke, Wallace P.*, Adjunct Associate Professor of Textile Engineering and Science. B.S., Northwestern Technological Institute.
- Beith, Barry Hamilton*, Adjunct Assistant Professor of Industrial Engineering. Ph.D., North Carolina State University.
- Belcher, Clifton Beryl*, Adjunct Assistant Professor of Occupational Education. Ed.D., North Carolina State University.
- Bell, Norman Robert*, Associate Professor Emeritus of Electrical and Computer Engineering. M.S., Cornell University.
- Bell, Thomas Alexander*, Professor Emeritus of Food Science. M.S., North Carolina State University.
- Bengston, Neal M.*, Assistant Professor of Computer Science and Industrial Engineering. Ph.D., Purdue University.
- Benson, David Michael*, Professor of Plant Pathology and Graduate Studies Coordinator. Ph.D., Colorado State University.
- Benson, Geoffrey Alan*, Associate Professor of Economics and Business. Ph.D., Pennsylvania State University.
- Benson, Ray Braman, Jr.*, Professor of Materials Science and Engineering. Ph.D., University of California at Berkeley.
- Bentley, Peter John*, Burroughs Wellcome Distinguished Professor of Anatomy, Physiological Sciences and Radiology. Ph.D., University of Western Australia, Nedlands, Australia.
- Bereman, Robert Deane*, Professor of Chemistry and Associate Dean for Academic Affairs, College of Physical and Mathematical Sciences. Ph.D., Michigan State University.
- Berenson, Sarah Burke*, Visiting Assistant Professor of Mathematics and Science Education. Ph.D., Florida State University.
- Berger, Robert L.*, Associate Professor of Statistics. Ph.D., Purdue University.
- Berkhoff, Herman A.*, Professor of Microbiology, Pathology and Parasitology. Ph.D., Cornell University.
- Berkstresser, Gordon Abbott, III*, Professor of Textile and Apparel Management and Head of the Department. Ph.D., City University of New York.
- Berlam, Robert A.*, Adjunct Assistant Professor of Adult and Community College Education. Ed.D., Nova University.
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The University of North Carolina opened its doors to students at Chapel Hill in 1795. Thereafter, beginning in the latter part of the nineteenth century, the General Assembly of North Carolina has established and supported fifteen other public senior institutions in keeping with Article IX, Section 8, of the Constitution of North Carolina which provides that the "General Assembly shall maintain a public system of higher education, comprising The University of North Carolina and such other institutions of higher education as the General Assembly may deem wise."

By 1969, The University of North Carolina included six constituent institutions, governed by a single Board of Trustees. This multi-campus University had its beginnings in legislation enacted in 1931 that defined The University of North Carolina to include The University of North Carolina at Chapel Hill, North Carolina State University at Raleigh, and The University of North Carolina at Greensboro. In the 1960's three additional campuses were added: The University of North Carolina at Charlotte, The University of North Carolina at Asheville, and The University of North Carolina at Wilmington.

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NORTH CAROLINA STATE UNIVERSITY

F


E

D

C

B

A

-  Access Key
 ● can be entered by an individual in a wheelchair with no assistance
 ○ can be entered by an individual in a wheelchair with minimum assistance
 N, S, E, W—indicates side of building with accessible entrance
 ■ passenger elevator
 ■ freight elevator
 T accessible toilet

ACCESS	NO.	BUILDING NAME
	1	Alexander Resid.
	2	Alumni Memor.
	3	Bagwell Resid.
	4	Bection Resid.
	5	Barry Resid.
	6	Blithmore Hall
	7	Bowen Resid.
	8	Bragaw Resid.
	9	Brooks Hall
● N, T	10	Brooks Hall Apts.
○ N	11	Broughton Hall
■ N	12	Burlington En.
■ E	13	Bureau of M.
	14	Carmichael G.H.
	15	Carroll Resid.
● N	16	Cass Athlet.
	17	Central Store
	18	Chancellor's H.

1

2

3

4



The Graduate School
Box 7102
Raleigh, North Carolina 27695-7102

101st Annual Commencement

North Carolina State University



Saturday, May 12
Nineteen Hundred and Ninety
Degrees Awarded 1989-90

DEGREES CONFERRED

Saturday, May 12
Nineteen Hundred and Ninety
Degrees Awarded 1989-90

This program is prepared for informational purposes only. The appearance of an individual's name does not constitute the University's acknowledgement, certification, or representation that the individual has fulfilled the requirements for a degree.

Honors listed for May 1990 candidates for degree are tentative in that they are calculated without the final semester grades.

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Musical Program

EXERCISES OF GRADUATION

May 12, 1990

Commencement Band Concert: 8:30 a.m.
Carter-Finley Stadium

Alleluia! Laudamus Te Alfred Reed

The Thunderer March John Philip Sousa

West Side Story Leonard Bernstein

Second Suite in F — March Gustav Holst

America the Beautiful Samuel Ward/Carmen Dragon

PROCESSIONAL: 9:00 A.M.

March Processional Clare Grundman

RECESSIONAL: (Platform Party Only)

University Grand March Edwin Franko Goldman

NORTH CAROLINA STATE UNIVERSITY COMMENCEMENT BAND
Dr. Ronald J. Toering, Conductor

MAYA ANGELOU



Ms. Maya Angelou is hailed as one of the great voices of contemporary black literature and as a remarkable Renaissance woman. Being a poet, educator, historian, best-selling author, actress, playwright, civil rights activist, producer and director, she continues to travel the world making appearances on college campuses, spreading her legendary wisdom. A mesmerizing vision of grace, swaying and stirring when she moves, Ms. Angelou captivates her audiences lyrically with vigor, fire and perception.

Ms. Angelou's background is as complex as the woman herself. Born in St. Louis, she spent the early part of her childhood in Stamps, Arkansas. Her family then moved to San Francisco where she completed her high school education. Determined to carve out a stage career, Ms. Angelou studied drama and dance. In 1952, her career took a significant upturn. She received a scholarship to study dance with Pearl Primus in New York. She then joined the European touring company of *Porgy and Bess*. She sang the role of "Ruby" and was the lead dancer in the show which was presented in twenty-two European countries.

Ms. Angelou lived in Africa where she became the associate editor of the *Arab Observer* in Cairo. She also was the assistant administrator of the School of Music and Drama at the University of Ghana. She concluded her stay in 1966 as feature editor of the *African Review* in Accra.

Random House has published ten bestsellers by Ms. Angelou: *I Know Why the Caged Bird Sings*, *Just Give Me a Cool Drink of Water 'Fore I Die*, *Gather Together in My Name*, *Oh Pray My Wings are Gonna Fit Me Well*, *Singin' and Swingin' and Gettin' Merry Like Christmas*, *And Still I Rise*, *The Heart of A Woman*, *Shaker, Why Don't You Sing?*, *All God's Children Need Traveling Shoes*, and *Now Sheba Sings the Song*. Ms. Angelou has the unique ability to shatter the opaque prisms of race and class between reader and subject throughout her books of both poetry and autobiographies.

In the sixties, at the request of Dr. Martin Luther King, Jr., Ms. Angelou became the Northern Coordinator for the Southern Christian Leadership Conference. She was also appointed by President Gerald Ford to the Bicentennial Commission, and by President Jimmy Carter to the Commission of International Women's Year.

In the film industry, especially through her work in script writing and directing, Maya Angelou has been a groundbreaker for black women. She was the writer of the screenplay *Georgia, Georgia*, which was the first original script by a black woman to be produced. She has also done numerous musical scores for her own films and others as well. Ms. Angelou was writer/producer for 20th Century Fox TV, for whom her film, "Sister, Sisters" was her first initial full-length effort.

In television, Ms. Angelou has made hundreds of appearances on both network and local talk shows. She was the subject of an hour interview with Bill Moyers on PBS. Her renowned autobiographical account of her youth, *I Know Why the Caged Bird Sings*, was a two hour TV special for CBS in 1979. Other significant television accomplishments include the five part mini-series, "Three Way Choice" on CBS, for which she was both the author and executive producer, and "Afro-American in the Arts" for PBS, for which she received the coveted Golden Eagle Award.

Drawing again upon her many talents, Ms. Angelou, in collaboration with Godfrey Cambridge, wrote, produced, and performed in the revue "Cabaret for Freedom." She also appeared with Cambridge in Jean Genet's play "The Blacks." This production later went on to win the Obie Award. In 1974, she wrote an adaptation of Sophocles' *Ajax* for the Mark Taper Forum in Los Angeles. Ms. Angelou's musical, "And Still I Rise," for which she is librettist, lyricist and composer, was first produced in 1976. Her most recent achievement is the production of "Moon on a

Rainbow Shawl," in which Ms. Angelou directs the play written by Errol John. This production opened in May, 1988 in London, England.

Ms. Angelou's awards and honors are unlimited in virtually every field. To mention only a few, she received the Chubb Fellowship Award from Yale University in 1970; was nominated for the National Book Award in 1970 for *I Know Why the Caged Bird Sings*; a Pulitzer Prize nomination in 1972 for *Just Give Me a Cool Drink of Water 'Fore I Die*; and a Tony Award nomination in 1973 for her performance in "Look Away." Ms. Angelou was presented two awards from *Ladies Home Journal*: one for Woman of the Year in Communications (1976), and one for the Top 100 Most Influential Women (1983). She has received doctorate degrees from Smith College, Mills College and Lawrence University. In 1977, Ms. Angelou was nominated for an Emmy Award for her role in Alex Haley's "Roots." In 1981, Ms. Angelou was appointed to a lifetime position as the first Reynolds Professor of American Studies at Wake Forest University in North Carolina. The Matrix Award in 1983 was another honor along with the North Carolina Award in Literature, the highest the state bestows, in 1987.

Ms. Angelou has had countless articles in a world of publications including *Life*, *Cosmopolitan*, *Essence*, *Harper's Bazaar*, and *The New York Times*. She speaks French, Spanish, Italian, Arabic and West African Fanti.

Infused with passion and an exuberant vitality, Ms. Angelou believes in social change for the betterment of those who have not shared fully in the American dream. She continues her work and lectures throughout the country and abroad about the black experience, the human condition . . . about what we can endure, dream fail at the still survive.

The Alma Mater

Words by:

ALVIN M. FOUNTAIN, '23

Music by:

BONNIE F. NORRIS, JR., '23

Where the winds of Dixie softly blow
o'er the fields of Caroline,

There stands ever cherished N. C. State,
as thy honored shrine.

So lift your voices; Loudly sing
from hill to oceanside!

Our hearts ever hold you, N. C. State
in the folds of our love and pride.

Exercises of Graduation

Carter-Finley Stadium

Chancellor Larry K. Monteith
Presiding

May 12, 1990

PROCESSIONAL, 9:00 a.m. Dr. Ronald J. Toering
Conductor, North Carolina State University Commencement Band

The audience is requested to remain seated during
the Processional.

WELCOME Chancellor Larry K. Monteith

INVOCATION The Reverend William G. Sharpe, IV
Director, Raleigh Wesley Foundation
United Methodist Campus Minister
North Carolina State University

NATIONAL ANTHEM Sgt. Frederick A. Parmley

INTRODUCTIONS Chancellor Monteith

GREETINGS President C. D. Spangler, Jr.
The University of North Carolina

ADDRESS Ms. Maya Angelou
Reynolds Professor of American Studies

CONFERRING OF DEGREES Chancellor Monteith

Candidates for Doctor of Veterinary Medicine pre-
sented by Dean of College of Veterinary Medicine.
Candidates for other advanced degrees presented
by Dean of Graduate School. Candidates for bacca-
laureate degrees presented by Deans of Colleges/
Schools.

ADDRESS TO FELLOW GRADUATES Mr. Timothy Van Cooke

RECOGNITIONS Chancellor Monteith

VALEDICTORIANS—CLASS OF 1990

ALMA MATER Sgt. Frederick A. Parmley

RECESSIONAL (Platform Party only)

Commencement Ushers

Army ROTC Ushers

Glen Blumhardt
B. DeWayne Brank
Brian Burkett
Diane Carver
Curtis M. Hargrar
Kevin Hart
Bruce Horton
Al Linn
Virgil Matthews
Jim McFayden
Tom McFayden
John T. Rawcliffe
Matt Richmond
Alick Smith
Brett Yauger
William Yerkes

Navy ROTC Ushers

Andrew D. Amidon
Michael B. Beasley
Richard L. Biggs
Matthew I. Borbash
David H. Deboskey
Susan M. Graham
Michael W. Howell
Rafael E. Jimenez
Charlie D. Johnson
Herbert A. Kupec
William J. Pierce
Jeffrey A. Roach
Curtis C. Tucker
Mikele Winters

Air Force ROTC Ushers

Scott H. Bowes
Keith Cameron
Jeffrey T. Cook
Eric Critchley
Mark W. Johnson
Ronnie S. King, Jr.
David J. LeCount
Tracy Mitchelson
Lida M. Pilotta
Stan Rosen
Jeffrey B. Satterwhite
Keith S. Shaneman
Kevin S. Slaughter
Robert F. Taylor, Jr.
Michael D. Tynismaa
Mark D. Workman

Commencement Marshals

Patricia Adeleke
Eric Kpakpo Addo
Burton F. Beers, Jr.
Barbara L. Bernhard
Brian M. Buroker
Kevin R. Campbell
Richard Youngho Choi
Sarita Chung
Andrew R. Cruickshank
Julie A. Cudd
Jennifer E. Culler
John E. Davis
Tamie C. Daniels
Jennifer B. Fu

Kim Hale
Marnie Hamer
Frank B. Hicks, III
Johanna E. Hicks
William L. Holmes
David M. Honea
Ronald S. Jackson
Kim Jenkins
Linda N. Jones
John N. Kandara
Vince Lancaster
Lora A. Long
Lauri C. Lyerly

C. Donel Mitchell
Brad D. Moore
Leslie Powell
Kimberly L. Rowell
Julie C. Spaeth
Amr A. Swede
Anne E. Stubbins
Donnie A. Williams, Jr.
Ellen M. Williams
Toni M. Williams
Jeffrey T. Willits
Angela P. Wooten
Cynthia E. Zuckerman

Faculty Retirements 1989-90

- Adams, William McChesney, College of Veterinary Medicine, retired August 31, 1989.
- Allison, Richard Coffey, College of Forest Resources, retired August 31, 1989.
- Black, Chester Dunlap, College of Agriculture and Life Sciences, retired December 31, 1989.
- Campbell, William Vernon, College of Agriculture and Life Sciences, retired December 31, 1989.
- Coster, John Kincaid, College of Education and Psychology, will retire May 15, 1990.
- Craig, Harris Bradford, College of Agriculture and Life Sciences, retired July 31, 1989.
- Dolce, Carl John, College of Education and Psychology, will retire June 30, 1990.
- Drews, Frederick Richard, College of Humanities and Social Sciences, retired December 31, 1989.
- Ekwall, John Algot, College of Engineering, will retire June 30, 1990.
- Gilbert, Richard Dean, College of Textiles, will retire May 15, 1990.
- Griffith, Wayland Coleman, College of Engineering, will retire May 15, 1990.
- Halperen, Max, College of Humanities and Social Sciences, will retire May 15, 1990.
- Hamann, Hans Kermit, College of Physical and Mathematical Sciences, retired August 31, 1989.
- Huish, Melvin Theodore, College of Agriculture and Life Sciences, retired November 4, 1989.
- Kahn, Joseph Stephan, College of Agriculture and Life Sciences, retired August 31, 1989.
- Lord, Peter Reeves, College of Textiles, will retire May 15, 1990.
- Marsh, Culpepper Paul, College of Humanities and Social Sciences, retired December 31, 1989.
- Michaels, Alan Sherman, College of Engineering, retired September 30, 1989.
- Miller, Conrad Henry, College of Agriculture and Life Sciences, retired December 31, 1989.
- Petrea, Howard Aldridge, College of Physical and Mathematical Sciences, will retire June 30, 1990.
- Redeker, Immo Heinz, College of Engineering, retired April 30, 1990.
- Saylor, LeRoy Charles, College of Forest Resources, retired January 31, 1990.
- Stewart, James Mustian, Water Resources Institute, retired October 31, 1989.
- Tarver, Fred Russell, Jr., College of Agriculture and Life Sciences, retired September 30, 1989.
- Troxler, Robert T., College of Education and Psychology, will retire May 15, 1990.
- Turner, William Lindsay, Extension and Public Service, retired December 31, 1989.
- Wallace, James C., College of Humanities and Social Sciences, will retire May 15, 1990.
- Webb, Benjamin Davis, College of Education and Psychology, will retire May 15, 1990.

Time and Location of Distribution of Diplomas

College and Department Locations

College of Agriculture and Life Sciences—1:30 p.m.

Adult and Community College Education ... Room 1C-D, McKimmon Center,
Western Boulevard

Agricultural Business Management and Agricultural

Economics Main Floor, Reynolds Coliseum

Agronomy, Crop Science, Soil Science

and Conservation 2215 and 2223 Williams Hall

Animal Science Room 2, McKimmon Center

Biochemistry University Room, Faculty Club

Biological and Agricultural Engineering Weaver Laboratories Pavilion

Biological Sciences 2722 Bostian Hall

Biological Sciences Major

Botany

Ecology

Entomology

Genetics

Microbiology

Nutrition

Pest Management

Plant Pathology

Toxicology

Food Science 105 Schaub, Food Science Building

Horticultural Science NCSU Arboretum, Beryl Road

Individualized Study Program Location of Major Faculty Adviser

Poultry Science Baptist Student Center, 2702 Hillsborough Street

Applied Sociology 218 Withers Hall

Zoology 3712 Bostian Hall

Fisheries and Wildlife Sciences

Medical Technology

Zoology Majors

School of Design—1:30 p.m. Stewart Theatre

Reception—2:30 p.m. Brooks Hall Courtyard

College of Education and Psychology—1:30 p.m. except for those marked with an asterisk

*Administration and Supervision—1:00 p.m. 220 Poe Hall

Adult and Community College

Education Room 1C-D McKimmon Center, Western Boulevard

*Counselor Education—12:00 p.m. 532 Poe Hall

*Curriculum and Instruction, Special Education,

and Middle Grades Education—12:00 South Wing, Dining Hall

*Education General Studies—1:00 p.m. 220 Poe Hall

*Mathematics and Science Education—1:00 p.m. 216 Poe Hall

*Occupational Education: Agricultural Education, Health

Occupations Education, Industrial Arts/Technology Education

Industrial and Technical Education, Marketing Education,

and Occupational Education—12:00 p.m. Room 8, McKimmon Center

*Psychology—12:00 216 Poe Hall

College of Engineering—1:30 p.m.

Biological and Agricultural Engineering Weaver Laboratories Pavilion

Chemical Engineering Thompson Theater

Civil Engineering Lobby of Mann Hall

Computer Science 240 Nelson Hall

Electrical and Computer Engineering	Governor Holshouser Building
	N.C. State Fairgrounds
Furniture Manufacturing and Management	Ballroom, Faculty Club
Industrial Engineering	Ballroom, Faculty Club
Integrated Manufacturing Systems Engineering	Walnut Room, University Student Center
Masters of Engineering	Walnut Room, University Student Center
Materials Science and Engineering	McKimmon Center
Mechanical and Aerospace Engineering	University Student Center Ballroom
Nuclear Engineering	North Portico, Burlington Engineering Laboratories

College of Forest Resources—1:30 p.m. Area 1 A and B,
McKimmon Center, Western Boulevard

College of Humanities and Social Sciences—1:30 p.m.

Accounting	Daniels Middle School Auditorium, 2816 Oberlin Road
Business Management and Economics	Main Floor, Reynolds Coliseum
History	100 Harrelson Hall
English	West Raleigh Presbyterian Church, 27 Horne St.
Foreign Languages and Literatures	West Raleigh Presbyterian Church, 27 Horne St.
Multi-Disciplinary Studies	West Raleigh Presbyterian Church, 27 Horne Street
Philosophy and Religion	West Raleigh Presbyterian Church, 27 Horne St.
Political Science	Caldwell Hall Patio (Rain: Caldwell Hall Lobby)
Sociology	218 Withers Hall
Speech-Communication	Raleigh Civic and Convention Center Assembly Hall # 1, 500 Fayetteville Street Mall

College of Physical and Mathematical Sciences—1:30 p.m.

Chemistry	124 Dabney Hall
Mathematics	222 Dabney Hall
Physics	206 Cox Hall
Statistics	Erdahl-Cloyd Wing, D.H. Hill Library Room 2320
Marine, Earth and Atmospheric Sciences	2010 Biltmore Hall

College of Textiles—1:30 p.m. Forest Hills Baptist Church
3110 Clark Avenue

ROTC COMMISSIONING CEREMONY

COLONEL JAMES T. FERRELL
Presiding

Stewart Theatre
May 12, 1990

PROCESSIONAL MARCH, 4:00 p.m. Dr. Ronald J. Toering
Conductor, North Carolina State University Commencement Band

NATIONAL ANTHEM

INVOCATION Major R. Eric Jewett
Chaplain, Seymour Johnson AF, NC

INTRODUCTIONS Colonel James T. Ferrell

WELCOME Dr. Larry K. Monteith
Chancellor, North Carolina State University

INTRODUCTION OF GUEST SPEAKER Colonel James T. Ferrell

ADDRESS Major General John L. Borling
Director of Operations, Strategic Air Command

ADMINISTRATION OF THE OATH

OF OFFICE Lieutenant Colonel Howard K. Fisher, Jr.
Professor of Military Science
Colonel G. H. Walls
Professor of Naval Science
Colonel James T. Ferrell
Professor of Aerospace Studies

PRESENTATION OF CERTIFICATES Dr. Larry K. Monteith

BENEDICTION Major R. Eric Jewett

RECESSIONAL Dr. Ronald J. Toering
The audience is requested to remain seated until the Recessional music is completed.

Academic Costume

Academic gowns represent a tradition handed down from the universities of the Middle Ages. These institutions were founded by the Church; the students, being clerics, were obliged to wear the prescribed gowns at all times. Round caps later became square mortarboards; the hoods, originally cowls attached to the gowns, could be slipped over the head for warmth.

Many European universities have distinctive caps and gowns which are different from those commonly used in this country. Some of the gowns are of bright colors and some are embellished with fur. A number of these may be noted in the procession.

The usual color for academic gowns in the United States is black. The bachelor's gown is worn closed, the master's and doctor's may be worn open or closed. The shape of the sleeve is the distinguishing mark of the gown: bachelor—long pointed sleeves; master—oblong, square cut in the back with an arc cut away in front; doctor—bell shaped.

Caps are black. The tassels for the Ph.D. degree are gold and those for other graduate and professional degrees may be of the color corresponding to the trimmings on the hoods.

Of all the components of the academic costume, the hood bears the heaviest symbolic burden. The hood must make clear the level of the degree, the faculty in which it was given, and the institution which awarded it. The level of the degree is shown by the size of the hood, the width of the velvet trimming, and in the case of doctors, by the shape. The bachelor's, master's, and doctor's hoods are three feet, three and one-half feet, and four feet long, respectively. The velvet trimming in the same order is two, three, and five inches and extends all around the hood on the exposed edge. This same trimming identifies the faculty in which the degree was awarded. For each faculty there is a corresponding color; so a glance at the trimming is all that is needed to identify the faculty. A *partial* list of the colors follows: Agriculture, maize; Architecture and Art, brown; Science, golden yellow; Economics, copper; Education, light blue; Engineering, orange; Forestry, russet; Physical Education, sage green; Religion, scarlet; Speech, silver gray; Veterinary Medicine, gray; Textiles, wine red. The following faculties have the same color—dark blue: Anthropology, History, Languages, Literature, Philosophy, Political science, Sociology.

Academic Honors

Honors participants benefit from a more individualized and rigorous approach to their desired degree through special classes, seminars and individual research.

Undergraduate degree honor designations are:

Cum Laude—for GPA 3.250 through 3.499

Magna Cum Laude—for GPA 3.500 through 3.749

Summa Cum Laude—for GPA 3.750 and above.

UNDERGRADUATE DEGREES

College of Agriculture and Life Sciences



BACHELOR OF SCIENCE IN BIOLOGICAL AND AGRICULTURAL ENGINEERING

Jointly administered by the College of Agriculture and Life Sciences and the College of Engineering.

Degrees Conferred June 27, 1989

Bobby Alan Cunningham McLeansville
John Taylor Kittrell Corapeake

Degree Conferred August 9, 1989

Maxwell Raye Fowler Cashiers

Degrees Conferred December 19, 1989

Michael Poindexter Dixon, Jr. East Bend
Keith Mack Roberts Fayetteville

Degrees Conferred May 12, 1990

*Peter James Crawford Chapel Hill
John Dean Metcalfe Hendersonville
Byron Glenn Moore Nashville
Randall Keith Page Elon College
Stephanie Dianne Taylor Silver Spring, MD

BACHELOR OF SCIENCE IN CONSERVATION

Jointly administered by the College of Agriculture and Life Sciences and the College of Forest Resources. See page 41 under College of Forest Resources for a listing of the graduate seniors in the jointly administered program.

Degree Conferred June 27, 1989

Brian Antonio Ferebee Elizabeth City

Degree Conferred December 19, 1989

Michael Wayne Lanier Winnabow

† Co-major * Cum Laude ** Magna Cum Laude *** Summa Cum Laude H Honors Program

Degrees Conferred May 12, 1990

†***Selena Lee Armistead	Denver
Ralph Lee Hollowell, Jr.	Hobbsville
H†*Leslie Michelle Sullivan	Jacksonville
Linda Sue Wiggs	Wyckoff, NJ

BACHELOR OF SCIENCE IN AGRICULTURAL BUSINESS MANAGEMENT

Degree Conferred June 27, 1989

Harry Wayne Gooch	Stem
-------------------	------

Degrees Conferred December 19, 1989

Mary Kristina Bass	Lucama
Steven Phillip Fleming	Statesville
Agueda Marin-Hernandez	San Jose, CA
Timothy Tyler Mericka	Browns Summit
†Russell Louis Peele	Kenly
Bruce Terrell Roberts	Lenoir
Jack Lionel Todd	Whiteville

Degrees Conferred May 12, 1990

Elizabeth Marie Barker	Raleigh
***Randy Keith Baucom	Monroe
Timothy Van Cooke	Mount Airy
H*Ronald Mark Garrett	Durham
Carmon Kirk Gray	Stony Point
Obie Lee Kirkman, Jr.	Cove City
H†Brian Thomas Larson	Raleigh
Robert Todd Long	Raleigh
†Scott William Reece	Candor
Matthew Bennett Vincett	Raleigh
†Joseph Scott Welch	Anniston, AL

BACHELOR OF SCIENCE IN AGRICULTURAL BUSINESS MANAGEMENT—INTERNATIONAL OPTION

Degree Conferred December 19, 1989

†***James Matthew Matson	Eden
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BACHELOR OF SCIENCE IN AGRICULTURAL ECONOMICS

Degree Conferred June 27, 1989

Kevin Lee Owenby	Morganton
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Degree Conferred December 19, 1989

**Cornelis Leonard Van Staalduin	Pantego
----------------------------------	---------

Degrees Conferred May 12, 1990

†Scott William Reece	Candor
Talmdage Ray Wall, Jr.	Knightdale

BACHELOR OF SCIENCE IN AGRONOMY

Degrees Conferred December 19, 1989

*Mitchel John Dawes	Hendersonville
Donald Grey Nicholson	Sanford

† Co-major * Cum Laude ** Magna Cum Laude *** Summa Cum Laude H Honors Program

Scott Alan Tyson	Nashville
Waitus Craig West	Fremont

Degrees Conferred May 12, 1990

***Felicia Adair Cope	Winston-Salem
†Andrew Quinton Eure, Jr.	Williamston
*Daren Lee Hubers	Pantego
*Ronald Edward Kelly	Candor
David Barnes Langston, Jr.	Gates
†Brian Douglas Mitchum	Cary
Audie Morris Murphy	Snow Hill
*Joseph Franklin Scott, Jr.	Kenly

BACHELOR OF SCIENCE IN ANIMAL SCIENCE

Degrees Conferred June 27, 1989

*David Christopher Booker	Belmont
April Enola Kemper	Ewing Township, NJ

Degrees Conferred August 9, 1989

*William Richard Cooper	Charlotte
Andrew Marvin Elmore, Jr.	Fallston
Martha Jane Meador	Ruffin
Elizabeth Rutherford Wentz	Flint Hill
Sharon Yvonne Zeigler	Cary

Degrees Conferred December 19, 1989

Jeffrey Thomas Banfield	Southern Pines
*Jenna Lynne Blackwell	Charlotte
Philip Andrew Blalock	Rougemont
*Glenn Carroll Bradshaw, Jr.	Rose Hill
†Sherry Lorinda Burroughs	Cary
Heath Rayburn Byrd	Wilkesboro
†Angela Dawn Conner	Cary
Joseph Kahn Fountain	Beulaville
*Martha Ann Hunt	Durham
Kang Ho Kim	Raleigh
Charles Herbert Lane, Jr.	Jackson
William Kent Lytle	Old Fort
†*Leanne Nicholson	East Bend
Victoria Hope Nowell	Raleigh
Becky Anne Ownbey	Black Mountain
†Mark Lynn Ritchie	Concord
Elizabeth Taber Robb	Raleigh
*Kevin John Rowles	Knightdale
Cynthia Diane Stewart	Star
†Jarrett Cecil Terry	Raleigh
Lori Ann Wilberding	Gaithersburg, MD

Degrees Conferred May 12, 1990

Darin Dwayne Alston	Greensboro
**Audrey Thabet Beam	Clemmons
Sharon Lynn Briles	Asheboro
***Maria Catherine Casey	Raleigh
Christopher Harold Coates	Kenly
Judith Smith Dees	Laurens, SC
Carol Marie Dribelbis	Raleigh
Kimberly Joyce Eaton	Cary

† Co-major * Cum Laude ** Magna Cum Laude *** Summa Cum Laude H Honors Program

	Randy Joe Foy	Mount Olive
	*Shelley Lee Galliher	Harmony
H***	Joyce Carol Greene	Collettsville
	Henry Matthew Herman	Shelby
H†	Brian Thomas Larson	Raleigh
	Edward Lee Nixon, Jr.	Hertford
†	Katrina Renee Postell	Andrews
*	Deanna Michelle Rhein	Raleigh
	Richard Rutledge Riddle	Raleigh
†	Kelan Noel Rogers	Salisbury
	Virginia Walton Smith	Robersonville
	Amanda Faith Sparks	Thomasville
*	Denise Ann Spencer	Columbia
	Patrick Lawrence Usher	Newton Grove
	Kevin Eugene Watkins	Deep Run
	Terry Duane Webb	Hickory
*	Mark Anthony Wellons	Princeton
*	Alexandra Maria Willie	Selden, NY
	Seung Eun Yang	Salisbury

BACHELOR OF SCIENCE IN APPLIED SOCIOLOGY

Degree Conferred June 27, 1989

*	Edward Dean Jones	Raleigh
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Degrees Conferred May 12, 1990

	Rodney Steven Harris	Bunnlevel
	Jill Merline Will	Raleigh

BACHELOR OF SCIENCE IN BIOCHEMISTRY

Degree Conferred June 27, 1989

	Stephanie Jeanne Porter	Raleigh
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Degrees Conferred August 9, 1989

	Kaysonnia Lytessia Hunt	Roaring River
	Lori Anne Nemmers	Wilmington
***	Nova Arnine Scheller	Raleigh

Degrees Conferred December 19, 1989

H*	Charles Edward Bailey	Garner
†	Robert Franklyn Burke	Raleigh
	Lisa Suzanne Campbell	Wilmington
	John Harper Goode	Charlotte
	LuWanda CarShena Hamlett	Yanceyville
*	Wanda Rene Harris	Winston-Salem
†**	Janice Patricia McKeller	Raleigh
**	James Kevin Pierce	Garner
	Kimberly Dawn Spencer	High Point
†	Jarrett Cecil Terry	Raleigh
†	Melanie Heather Walker	High Point
*	Sharon Kay Williams	Morrisville

Degrees Conferred May 12, 1990

H†**	James Lester Barbee IV	Hamlet
†	William Earl Blackwell, Jr.	Greensboro
H*	Rebecca Bullard-Dillard	Columbia, SC
†**	William Edward Burton III	Conover
†	Co-major	
*	Cum Laude	
**	Magna Cum Laude	
***	Summa Cum Laude	
	H Honors Program	

†Samuel Clay Chatmon, Jr.	Angier
†**Sung Jin Cho	Raleigh
H*John Terrell Crutchfield	Raleigh
Jefferson Earl Davis	Cary
†**Ted C Davis	Overland Park, KS
H*Cynthia Ruth De Haas	Wilmington
H†**Michelle Lynn DuBois	Dallas, TX
†Angela Lauren Evans	Burnsville
†Robin Elaine Freeman	Columbia, SC
H***Chandana Ganguli	Fayetteville
H***Margaret Elizabeth Guest	Fort Bragg
†Dennis William Hall	Garner
Rebecca Ann Hardman	Charleston, WV
†Wendy Noble Jefferson	Belhaven
Mark Eugene Lemons	Jamestown
Sharon Renee Lingle	Raleigh
†Kelly Ann Mace	Pinnacle
*Katherine Kennedy Moore	Fuquay-Varina
*Christopher August Philippart	Raleigh
***Kimberly Beth Respass Sadler	Pantego
Sharon Renee Sims	Snow Hill
John Victor Stauber	Memphis, TN
†Michael Thomas Stocum	Raleigh
†***Arles Allen Taylor	Carthage
†David Brennen Throneburg	Southern Pines
Carrie Ann Zimmerman Wilson	Erie, PA
†Karen Michelle Winningham	Winston-Salem
*Lisa Ruff Yakimovich	Charlotte

BACHELOR OF SCIENCE IN BIOLOGICAL AND AGRICULTURAL ENGINEERING TECHNOLOGY

Degree Conferred June 27, 1989

Susan Michelle Shumaker	Charlotte
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Degrees Conferred December 19, 1989

Randall Lee Burris	Newton
Daphne Mae Cartner	Mocksville
David Scott Coble, Jr.	Swan Quarter
John Wyatt Twisdale, Jr.	Smithfield

Degrees Conferred May 12, 1990

Thomas Finley Pace	Winston-Salem
Charles McLawhorn Whitehurst, Jr.	Goldsboro

BACHELOR OF SCIENCE IN BIOLOGICAL SCIENCES

Degrees Conferred June 27, 1989

Michelle Yvette Boone	Weldon
Letitia Leigh Roberts	Clyde

Degree Conferred August 9, 1989

H***Sue Ellen Mann	Raleigh
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Degrees Conferred December 19, 1989

H**Tammy Schmidt Armbrust	Greenbush, WI
Thomas William Greene	Shelby

† Co-major * Cum Laude ** Magna Cum Laude *** Summa Cum Laude H Honors Program

Kirk Alan Hawkins	Raleigh
†Suzanne Marie Leach	Burlington
*Anita Lynn Matthews	Coats
†**Janice Patricia McKellar	Raleigh
Thomas George Metzger	Flanders
†Thomas Richard Olsen	Wilmington, DE
Audra Lynn Pyecha	Lynchburg, VA
Craig Joseph Reilly	Raleigh
**Christine Woodbury Siwan	Raleigh
*Timothy Fisher Steppe	Charlotte
Eleny P. Tzamaras	Washington, DC
Terri Lynette Watkins	Wendell

Degrees Conferred May 12, 1990

John Thomas Adleta	Loveland, OH
†***Selena Lee Armistead	Denver
Sherry Denise Benson	Clayton
Brenda Hao Cao	Raleigh
Julia Anne Coronella	Fanwood, NJ
Carlan Elaine Downs	Stokesdale
†Angela Lauren Evans	Burnsville
†Edward Clark Farr, Jr.	Charlotte
H**Teresa Anne Fears	Wilson
*Charles Lynn Hemmingway II	Cary
Gregory David Herndon	Charlotte
**Amanda Jo Hunter	Winston-Salem
*Alice Michelle Ingram	Charlotte
†**Henry Herbert Jacumin, Jr.	Rutherford College
†Kelly Ann Mace	Pinnacle
Mark Judson Morrison	Burlington
Laura Christine Nutter	Charlotte
H**Christelle Elizabeth Reisser	Herndon, VA
Charles Jonathan Roberts	Hillsborough
Scott Henry Schultz	Raleigh
Thomas Byron Stevens III	Raleigh
**Darlene Trost	Rochester, NY
†**Christina Marie Whitley	Havelock
Pamela Leigh Wright	Davidson

BACHELOR OF SCIENCE IN BIOLOGICAL SCIENCES (Microbiology)

Degree Conferred June 27, 1989

Lisa Rann McClelland	Raleigh
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Degree Conferred August 9, 1989

Douglas Gene Hatcher	Chinquapin
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Degrees Conferred December 19, 1989

Dana Erika Bumgarner	Cary
†Robert Franklyn Burke	Raleigh
Ada Aurora Cachafeiro	Rio Piedras, Puerto Rico
Robert Lee Davis	Sparta
†Stephanie Ann Franks	Burlington
Kyle Reid Garriss	Rockingham
**Martina Maria Gratzl	Cary
†Melanie Heather Walker	High Point
Danny Marcellus Wright	Henderson

† Co-major * Cum Laude ** Magna Cum Laude *** Summa Cum Laude H Honors Program

Degrees Conferred May 12, 1990

†Kathy Anne Barnhill	Raleigh
Virginia Ann Best	Greenville
Susan Christine Carter	Raleigh
†Samuel Clay Chatmon, Jr.	Angier
Davelyn Anne Fitzsimmons	Troy, NY
Pamela Jo Glass	Frederick, MD
Sheila Ann Huggins	Greenville
Angela Rene Kelly	Matthews
Margaret Helen Knell	Fayetteville
†Edward William Schettino	Greensboro
†Michael Thomas Stocum	Raleigh
Diane Lynn Wadiak	Burlington

BACHELOR OF SCIENCE IN BOTANY

Degree Conferred December 19, 1989

Elizabeth Ann Strum	Kennett Square, PA
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Degree Conferred May 12, 1990

Amy Annette Venturella	Asheville
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BACHELOR OF SCIENCE IN FISHERIES AND WILDLIFE SCIENCES

Degrees Conferred December 19, 1989

H Kerri Lynn Bartel	Jacksonville
H*Rachel Jean Collins	Acton, MA
Timothy Franklin Crabtree	Pittsboro
William Sandford Edwards, Jr.	Laurinburg
James Lawrence Gowney	Atchison, KS
Michael Albert Hatley	Valdese
Jennifer Annabel Jarvis	Swan Quarter
Chaffey Hux Johnson	Vass
Edmund Randolph Temple	Gatesville
Steven Gregory Williams	Fuquay-Varina

Degrees Conferred May 12, 1990

Douglas Robert Blackwell	Charlotte
Todd Andrew Buchanan	Winston-Salem
Patricia Marie Purcell	Camden County
Steven John Trowell	Wilmington
William Graham Wescott	Camden

BACHELOR OF SCIENCE IN FOOD SCIENCE

Degrees Conferred May 12, 1990

Susan Renee Alexander	North Wilkesboro
Suzanne Nancy Haithcock	Cary
Stanley Gordon Leslie	Cary
Judith Lynn Lewis	Raleigh
Marco Meulink	Scheveningen, Holland
Lisa Christian Wilson	Durham

BACHELOR OF SCIENCE IN HORTICULTURAL SCIENCE

Degrees Conferred June 27, 1989

H*Kim Marie Halada	Cary
Paul Raymond Hendrix	Charlotte
*Coye Arvel Yates	Banner Elk

Degrees Conferred December 19, 1989

Kimberly Ann Adams	Morganton
Robert Louis Brake	West Point, VA
Dana Brown Cannady	Charlotte
Steven David Church	Lenoir
Douglas Bergen Cramer	Raleigh
Donna Bryant Davis	Zebulon
Jens Wolfhard Geratz	Chapel Hill
Charles Alva Hardie, Jr.	Montreat
Carol Haire Hunter	Raleigh
Anna Renea Jones	Erwin, TN
†Russell Louis Peele	Kenly
Martha Carol Poole	Semora
Katherine Sophia Sawtschenko	Raleigh
Joseph Lindsey Smith, Jr.	Zebulon
Crystal Michele Tate	Burlington
*Helen Hoge Tyler	Clarksville, VA
Jeffery Kurt Vance	Newland
Robert Benjamin Whisnant	Fayetteville
Reid Owen Whitehead	Clemmons
David Matthew Zaparanick	Dawson Springs, KY

Degrees Conferred May 12, 1990

Jon Scott Arnold	Winston-Salem
Burton Henry Dietz, Jr.	Raleigh
Krista Dumproff Gantt	Lincolnton
*Sabrina Noelle Grady	Seven Springs
William Philip Grantlin III	Wake Forest
Erich Wayne Gumto	Renfrew, PA
Jacob David Laughter	Hendersonville
H**Livia Marques-Cooper	Haileah, FL
†Brian Douglas Mitchum	Cary
Bryant Edwin Montague	Apex
Cheryl Lynn Noone	Raleigh
Frankie Weaver Pendergraph	Apex
†Joseph Scott Welch	Anniston, AL
Robert Michael Welker	Charles Town, WV

BACHELOR OF SCIENCE IN INDIVIDUALIZED STUDY PROGRAM

Degrees Conferred December 19, 1989

H†***Dane Kinard Fisher	Salisbury
†*Arthur R. Spruill III	Plymouth

Degrees Conferred May 12, 1990

†*Robert Meredith Alexander	Boone
†*Dinah Austin Vannoy	Taylorsville

BACHELOR OF SCIENCE IN MEDICAL TECHNOLOGY

Degree Conferred August 9, 1989

H Wendy Denise Tolbert Lenoir

Degree Conferred May 12, 1990

Leticia Elena De Leon Panama City, Panama

BACHELOR OF SCIENCE IN PEST MANAGEMENT FOR CROP PROTECTION

Degree Conferred December 19, 1989

Mounib Fares Aoun Fakeha

BACHELOR OF SCIENCE IN POULTRY SCIENCE

Degrees Conferred December 19, 1989

†Sherry Lorinda Burroughs Cary

†Angela Dawn Conner Cary

William Ray Crowe Lenoir

Tyron Price Daly Goldsboro

Peter Thomas Gilyard Winston-Salem

Meredith Gaye Hart Benson

†*Leanne Nicholson East Bend

Edward Brent Nunn Liberty

†Mark Lynn Ritchie Concord

Robert Paul Scott Raleigh

Degrees Conferred May 12, 1990

Clayton Keith Carter Wallace

Craig Steven Gentry Ennice

Marc Orlando Marsh Marshville

H**John Edward May Columbia, South America

H Christopher Patterson McNeill Broadway

Roy Howard McNeill, Jr. Seagrove

**Katharine Greer Palmer Winston-Salem

†Katrina Renee Postell Andrews

†Richard Rutledge Riddle Raleigh

Philip Curtis Shivar Goldsboro

Timothy Farrell Welch Robbins

Amy Lou Westmoreland Kernersville

Jeffrey David Wilson Bear Creek

BACHELOR OF SCIENCE IN ZOOLOGY

Degrees Conferred June 27, 1989

Brian Kevin Collins Lumberton

Jeffery John Pinkerton Havelock

Degrees Conferred August 9, 1989

H***Anita Jeannette Bailey Huntington, WV

*Boris Brglez Cary

Walter Hamlin Brown IV Petersburg, VA

Ronald Ray Cain High Point

James Anthony Caldwell Atlanta, GA

Sandra Marie Grant Chapel Hill

Elizabeth Brantley Shoemaker Henderson

† Co-major

* Cum Laude

** Magna Cum Laude

*** Summa Cum Laude

H Honors Program

Jacquelyn Deanne Wiley	Charlotte
Selina Yuen	Kingston, NY

Degrees Conferred December 19, 1989

Yolanda Yvette Boddie	Nashville
Callista Gail Brinkley	Hickory
*Ina Marie Broadwell	Angier
Laura Ann Conley	Raleigh
Shelli Raye Currin	Suffolk
Elizabeth Anne Dillingham	Arden
Jeri Jones Edwards	Mooreville
Donna Lynn Ellis	Angier
Jason Paul Evans	Greensboro
†Stephanie Ann Franks	Burlington
Susan Annette Hager	Warrenton, VA
Jason Philip Haritos	Budd Lake, NJ
Stephen Martin Hash	Winston-Salem
George Wesley Hatley	New London
***Renuka Pratap Karamchandani	Raleigh
John McGilvray Lucas	Charlotte
H***Katherine Burgan Meadows	Lewisville
Paula M. Oliver	Raleigh
Jamie Susan Payne	Statesville
Carla Michelle Rogers	Raleigh
Michael Curtis Rogers	Columbia, MD
James Derril Salter	Lumberton
Rita Arun Shendrikar	Cary
**Harrison Glendon Sims III	Oak Ridge
Melinda Lee Woods	New Bern

Degrees Conferred May 12, 1990

Nancy Marie Adams	Thomasville
Dana Ann Ahrenholz	Davis
Karla Ann Andrews	Southern Pines
Anthony Miles Armstrong	Fayetteville
H*Charles Stanford Armstrong, Jr.	Charlotte
H***Cynthia Ann Ballenger	Charlotte
Melissa Janet Baptist	Annandale, NJ
Kelly Miles Barefoot	China Grove
**Timothy Scott Barlow	Cary
†Kathy Anne Barnhill	Raleigh
***Jack Wayne Bowling, Jr.	Gastonia
H***Douglas Lewis Bunting, Jr.	Pinetops
**Anna Michelle Byrd	Coats
*Krista Ruth Cartledge	Andrews
Charlotte Linn Corriher	Landis
Marian Patrice Covington	Mebane
*Derward Lee Creech, Jr.	Cary
Theresa Lynn Cress	Salisbury
James William Crowson	Statesville
Whitney Renee Dibb	Fayetteville
H***Janet Lee Dow	Kinston
H†**Alston Elmo Dunbar III	Pantego
Peggy Sue Duncan	Whiteville
Linda Christina Fogelson	Charlotte
Jennifer Anne Miller Garnett	Raleigh
Tracey Rene Garrett	Washington, DC
Jeffrey McDonald Hall	Elizabethtown

† Co-major * Cum Laude ** Magna Cum Laude *** Summa Cum Laude H Honors Program

	Laurie Michelle Hanft	Miami Lakes, FL
**	Sheila Faith Hanley	Nashville, TN
H***	Laura Kay Hardin	Greensboro
	*Suzanne Marie Henkel	Boyertown, PA
	Stuart Spence Higgins	Amherst County, VA
**	Louisa Michelle Hight	Raleigh
H***	Laura Eve Hinrichs	St. Charles, IL
†**	Henry Herbert Jacumin, Jr.	Rutherford College
	Theresa Lynn Janifer	Washington, DC
H***	John Theodore Johnson, Jr.	Cary
	Monika Etra Johnson	Goldsboro
	*Donna Corbin Johnston	Fuquay-Varina
	Jesse Womble Jones	Fuquay-Varina
	Mehdi Mohammad Kazemi	Raleigh
	Karen Michelle Kennedy	Winston-Salem
H***	Rebecca Diane Kesler	Sanford
HPeter	Tae Woo Kim	Raleigh
	Stephen Augustus Kinard	Chester, PA
	Kimberly Dawn Kluckman	Fayetteville
	*Tracy Ann Ladue	Statesville
H	David Wayne Linzey	Blacksburg, VA
	Carol Ann Lowe	Greensboro
**	Sarah Joyce Maness	Greensboro
	Joy Lynn McElroy	Smithfield
H**	Kristin Lynn McKenzie	Bethania
	Christi Jean Meacombs	Raleigh
	Kristin Lee Mendorf	Raleigh
**	William Kenneth Miller	Asheville
	Manish Dhansukh Mistry	Charlotte
	Sharon Sharitha Mitchener	Columbia, SC
	William Paul Mitchum	Pittsboro
	Edward Scott Morrison	Pensacola, FL
	Elizabeth Grace Myles	Virginia Beach, VA
	Charles John Niemeyer, Jr.	Gastonia
**	Cynthia Ann Norris	Baltimore, MD
	Laura Christine Nutter	Charlotte
	*Lori Ann Patton	Clayton
†	Bastiaan Gerold Alexander Pennink	Fayetteville
	Rita Coley Person	Goldsboro
H**	Herbert Reiss Plauché	Baton Rouge, LA
	*Kamal Maganlal Ramani	Raleigh
***	Dana Michelle Reeves	Fayetteville
HElizabeth	Anne Rourke	Hickory
†	Edward William Schettino	Greensboro
	*Kevin Charles Schrimper	Raleigh
	Kelly Elizabeth Sexton	Asheboro
H**	Sandra Ann Shealy	North Wilkesboro
***	Ann Marie Simmons	Mount Airy
**	Tonya Miguel Sipe	Winston-Salem
H**	Crystal Renee Smith	Havelock
H*	Katherine Beatrice Smith	Greensboro
**	David James Sniffen	Monroe
	*Charlene Andrea Spann	Advance
	Robert Mark Steffens	Cary
	Martha Nell Stephenson	Fuquay-Varina
H†*	Leslie Michelle Sullivan	Jacksonville
	Gerald Bernard Taylor	Greenville
	Patrick Reed Terry	Winter Park, FL
	Kimberly Shirrell Thompson	Monroe

†David Brennen Throneburg	Southern Pines
Kimberly Noel Treat	Charlotte
George Wesley Tyler	Fayetteville
*Paul Edward Underwood	Goldsboro
*Robert Zachary Vinci	Binghamton, NY
*Shelly Lorraine West	Raleigh
Leslie Michelle Williams	Columbia, SC
Kristin Marie Yancey	San Diego, CA

School of Design



BACHELOR OF ARCHITECTURE

Degrees Conferred May 12, 1990

Robert David Appleyard, Jr.	Winston-Salem
Frank Ingram Ballard, Jr.	Wilmington
*John Clark Hipp	Charlotte
**Melissa Rae Holshouser	Sanford
Lisa Gardner Maune	Raleigh
Julie Marie McLaurin	Charlotte
*Christopher Alexander Rogers	San Francisco, CA
*Robert Franklin Smith	Wrightsville Beach
*Wojciech Szaszor	Gdansk, Poland
Eric Morgan Tjalma	Chapel Hill
Steven Andrew Triggiano	Raleigh
***Timothy Patrick Utecht	Satellite Beach, FL

BACHELOR OF ENVIRONMENTAL DESIGN

Degree Conferred June 27, 1989

***Mary Lou Herring	Fairmont
---------------------------	----------

Degree Conferred December 19, 1989

Christopher Allen Eselgroth	Rochester, NY
-----------------------------------	---------------

Degrees Conferred May 12, 1990

*Alan William Cavallaro	Conover
Catherine Elizabeth Gibhardt	Greensboro
*Aly Gamil Khalifa	Greenwich, CT
**Laura Suzanne Lambie	Winston-Salem
*Amy Rebecca Milne	Morganton
**Sarah Davidson Mountjoy	Raleigh

BACHELOR OF ENVIRONMENTAL DESIGN IN ARCHITECTURE

Degree Conferred June 27, 1989

Hall Morrison Johnston III Charlotte

Degrees Conferred August 9, 1989

*Kimberly Renee Brunkhurst Saugerties, NY
Maria Katherina Hunt Rutherfordton
Lisa Gardner Maune Raleigh
Anthony Aaron Pittman Hickory
David Samuel Rotman Asheville
Mark Alan Stephenson Pittsburgh, PA
Michael Shane Totten Bath
*Steven Andrew Triggiano Raleigh

Degrees Conferred December 19, 1989

Souheil Salim Al-Awar Raleigh
William Stuart Armstrong Raleigh
*John Natale Barbara Raleigh
Shelley Sanders Foley Raleigh
David Alan Gieser Des Moines, IA
**Barry Paul Icard Conover
†Craig Christopher Lewis Boiling Springs
Jonathan William McComas Beaufort
*Stephanie Ann Murrill Wilmington
**Kurt Edward Schwartz Raleigh
†John Taboada Rockville, MD
Michael Giles Van Staagen Greenville

Degrees Conferred May 12, 1990

Roy Lee Abernathy Morganton
Amy Frances Allgeyer Graham
Catherine Skelton Browne Mount Airy
David Patrick Bryson Charlotte
Robert James Carhuff, Jr. Fayetteville
**Curtis Hoffmann Chi Conover
Jerry Darrell Fink Salisbury
Stephen Ellis Halsey Durham
Arthur William Francis Illingworth, Jr. Raleigh
**Bronald Clay Johnson Winston-Salem
Tika Lucia Johnson Raleigh
John Phillip Kennett, Jr. High Point
Esmeralda McMeans Goldsboro
*Matthew Dale Messick Greensboro
Amanda Andrews Mueller Raleigh
Charles Martin Neese Whitsett
Myrna Amelia Olmos Muniz San Juan, Puerto Rico
Griffith Anderson Pearson Charlotte
Herbert Pearce Scott, Jr. Wilmington
Dean Edward Smith Southport
*George Leonidas Tsappas Limassol, Cyprus
Thomas Forrest Van Keuren, Jr. Petersburg, VA
*John William Wright Greensboro

† Co-major

* Cum Laude

** Magna Cum Laude

*** Summa Cum Laude

H Honors Program

BACHELOR OF ENVIRONMENTAL DESIGN IN LANDSCAPE ARCHITECTURE

Degree Conferred June 27, 1989

**Nancy Ellen Eletto Raleigh

Degrees Conferred December 19, 1989

*Matthew Harman Allison Cleveland

**Nicola Helen Godfrey Pound Ridge, NY

*Jill Alison Schott Raleigh

†John Taboada Rockville, MD

Degrees Conferred May 12, 1990

*Melissa Dalla Pozza Dean Raleigh

***Tana Joy Doherty Raleigh

*Jennifer Lee Hooks Greensboro

Alyn James Janis, Jr. Berlin, MD

BACHELOR OF ENVIRONMENTAL DESIGN IN PRODUCT DESIGN

Degrees Conferred June 27, 1989

*Amy Diane Coiner Washington

Timothy Pinckney Fletcher Matthews

*Brian Hargrove Leonard Durham

Eric Morris Woodard Wilson

Degrees Conferred December 19, 1989

*Bryan Davis Ayers Kernersville

*Julian Trapp Bryan Raleigh

Robert Roger Lasson Raleigh

†*Craig Christopher Lewis Boiling Springs

Michael Robert Wells Raleigh

Degrees Conferred May 12, 1990

David Rutledge Giles Cary

Guy Aloysius Marshall Wadesboro

Geoffrey Earl McGhee Franklinton

Michael Eugene Moon Graham

David Gayland Surridge Fayetteville

Alfred Reneau VanLandingham, Jr. Charlotte

***Stephen Elliott Wald Winston-Salem

BACHELOR OF ENVIRONMENTAL DESIGN IN VISUAL DESIGN

Degree Conferred June 27, 1989

Miren Terese Zubizaretta Caracas, Venezuela

Degrees Conferred August 9, 1989

Laura Marie Boone Raleigh

Nicholas Paul Patella, Jr. Winston-Salem

Degrees Conferred December 19, 1989

Kathryn Michelle Brown Wilmington

Dianne Elizabeth Fodrie Charlotte

*Robert Bentley Graham Greensboro

Don Houston Harris, Jr. Forest City

+ Co-major

* Cum Laude

** Magna Cum Laude

*** Summa Cum Laude

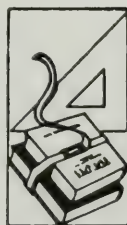
H Honors Program

April Elaine Jones	Roanoke Rapids
Jamieson Elizabeth Lewis	Fayetteville
Teresa Elaine Mock	Raleigh
Brett Alan Poole	High Point
Christopher Austin Vice	Raleigh

Degrees Conferred May 12, 1990

Heather Anne Allen	Winston-Salem
*Wade Ferguson Dansby III	Chapel Hill
Andrea Lynn Duckett	Niagara Falls, NY
Katherine Lizbeth Fowler	Raleigh
***Rebecca Taylor Garrison	Rocky Mount
Lisa Lorraine Helms	Durham
Rodney Lane Holland	Newton Grove
Donna Marie Kanna	Lancaster, SC
James Brian Keller	Charlotte
**Timothy Dean Kirkman	Wingate
**Alison Grey Lackey	Hickory
***Asa Birgitta Nordin	Falun, Sweden
**Lynn Bullard Powell	Raleigh
**Tanya Ann Quick	Goldsboro
*Alan Keith Reische	Salisbury
Amanda Phyllis Williams	Walkertown
Nathaniel Williams, Jr.	Winston-Salem

College of Education



BACHELOR OF ARTS IN PSYCHOLOGY

Degrees Conferred June 27, 1989

Victoria Lynn Chesnutt	Elizabethtown
Katherine Anne Fleming	St. Petersburg, FL
Deanna Janell Hicks	Bunn
Catherine Denise Hord	Shelby
Robin Michele Knittel	Fairfield, CT
Michael Gerard Mersch	Cincinnati, OH
Gerald Franklin Redwine, Jr.	Cary
Victoria Eugenia Shaw	Kings Mountain
**Joan Annette Styles	Burnsville
**Kim Rosan Tousignant	Raleigh
Angela Lynn Wood	Vienna, VA

† Co-major

* Cum Laude

** Magna Cum Laude

*** Summa Cum Laude

H Honors Program

Degrees Conferred August 9, 1989

Amanda Wyatt Cutts	Cary
*William Timothy Dick	Cary
Stephanie Jo Irby	Silver Spring, MD
Robin Marie McGowan	Raleigh

Degrees Conferred December 19, 1989

Lee Chandler Bass	High Point
Kathryn Lynn Bell	Virginia Beach, VA
Toby Bruce Brannan	Goldsboro
Yvon Cole Colgan	Cary
*Virginia Ann Edwards	Fayetteville
Kevin Wade Green	Apex
Harvey Glenn Langston III	Raleigh
***Joseph Clair McClintock	Raleigh
Mary Elizabeth Pace	Jacksonville
Donna Kaye Smith	Kinston
Elizabeth Ann Smith	Monroe
***Scott Alan Smith	Durham
Terry Lynch Taylor	Sanford
Audrey Dawn Turnley	Rocky Mount
Alice Wilson Walker	Cary

Degrees Conferred May 12, 1990

Craig Thomas Barber	Durham
Eric Randall Beacham	Yaupon Beach
Gena Denise Bos	West Palm Beach, FL
*Caroline Marcia Brooks	Concord
*Kathleen Elizabeth Chipley	Warrenton, VA
Hope Yvette Clark	Winterville
Ginger Diane Cockrum	Winston-Salem
Shannon Lea Cunningham	Chapin, SC
Linda Susan Donovan	Cary
William Ervin Duckworth, Jr.	Meadville, PA
**Tina Gaye Fletcher	High Point
Sandra Lucille Franklin	Greenville, SC
Laura Rae Green	Pittsboro
H*Sumedha Gupta	Raleigh
Lisa Marie Higdon	Ellicott City, MD
*Teresa Dent Hill	McLeansville
Robin Elaine Howell	New Bern
**Richard Allen Masi	Danbury, CT
**Lori Rose Moore	Cary
**Shari Lynn Murner	Fayetteville
**Carolina Ordonez	Columbia, MD
†Bastiaan Gerold Alexander Pennink	Fayetteville
Shannon Elizabeth Perry	Raleigh
Michael Joseph Pigliacelli	Williamston, NJ
Diane Lynn Prosser	Huntsville, AL
Patricia Ann Quinn	Sanford
Logan Lester Rothstein	Raleigh
Jennifer Marie Seymour	Fayetteville
*Rachel Janice Spangler	Monroe
†Leanne Stepanovich	Altoona, PA
Cynthia Sherrill Strickland	Durham
*Debbie Lynn Strickland	Middlesex
Charles Rush Taylor	Linville
*Ross Carlyle Teague	High Point

† Co-major

* Cum Laude

** Magna Cum Laude

*** Summa Cum Laude

H Honors Program

H Evan Eugene Upchurch	Maggie Valley
***Mary Anna Willingham	Kenansville

BACHELOR OF SCIENCE IN EDUCATION

Agricultural Education

Degree Conferred June 27, 1989

Anna Marie Gerringer	Gibsonville
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Degree Conferred August 9, 1989

**Chester Bryan Hooten	La Grange
------------------------------	-----------

Degrees Conferred December 19, 1989

Timothy Van Cooke	Mount Airy
*Gina Laraine Moxley	Boonville
Curtis Keith Whitley	Hays

Degrees Conferred May 12, 1990

Caswell Hobson Booe	Yadkinville
***Troy Eugene Coggins	Denton
Terry Wayne Currin	Lillington
Gregory Albert Davis	Vale
***Margaret Donohue Hardin	Hillsborough
Jacqueline Ussery Morgan	Star
Wendy Sue Norris	Garland
*Ricky Joe Warren	Clinton
John Kinder Watlington	Yanceyville
Warren Albert Williams	Benson

General Studies

Degree Conferred June 27, 1989

Cassandra Patrice Spears	Washington, DC
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Degrees Conferred December 19, 1989

Chris Johnson	Beaufort
Katherine Capers Lipscomb	Auburn, AL
Melissa Ann Seaboldt	Reidsville

Degrees Conferred May 12, 1990

Andrea Lawrence	Cape Vincent, NY
Rhonda Kay Ragland	Brevard
Charise Ovalle Roberts	Dudley
Angela Lee Shook	Advance
Joseph Timothy Warren	Roanoke Rapids

Health Occupations Teacher Education

Degree Conferred June 27, 1989

**Rhea Tyler Carey	Detroit, MI
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Degree Conferred August 9, 1989

***Linda Karlhofer Rogers	Raleigh
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Degrees Conferred December 19, 1989

*Judy Ernst Haynes	Sanford
***Cynthia Thiele Long	Fuquay-Varina
*Linda Allison Rabon	Garner
**Kimberly Ayscue Thomas	Henderson

Degrees Conferred May 12, 1990

*Bridget McCafferty Barry	Buffalo, NY
**Dana Poovey Caffey	Raleigh
***Danny Lee Campbell	Durham
***Teresa Creech Campbell	Raleigh
***Rita Mitchell Criswell	Cary
***Marilyn Miller Davis	Raleigh
Pamela Lynne Morrison	Goldsboro
*Debra Elaine Viands	Williamsport, MD

Industrial Arts Education

Degree Conferred December 19, 1989

*Karl Frederick Smink	Raleigh
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Degrees Conferred May 12, 1990

*Michael Robert Batchelor	Zebulon
Charles Brent Boone	Charlotte
**James Douglas Caliri	Wayne, NJ
Gregory Grady Gambill	Piney Creek
William Edward Mingin, Jr.	Smithfield, VA
**Harden Ricci	Cary
David Jeffrey Scott	Kinston
Maurice Julian Teague	Bennett

Marketing Education for Teachers

Degrees Conferred May 12, 1990

Melea Lemon Bryan	Cary
†Sandra Joette Thomas	Pittsboro
Koren Leah Wilkerson	Raleigh

Mathematics Education

Degrees Conferred December 19, 1989

**Cynthia Whyte Bothwell	Durham
Brian Lee Chapman	Lake Toxaway
*Marsha Leigh Crispin	Creswell
Michael Nolan Davis	Winston-Salem
*Kelly Patrick Fitzgerald	Green Bay, WI
**Margery Leigh Hollis	Charlotte
Sun Joo Kim	Fayetteville
*Todd Allen Moore	Reidsville
Tracy Norman Patrum	Mount Pleasant
Tracy York White	Evanston, IL

Degrees Conferred May 12, 1990

***Mark William Boyce	Monroe
Darla Jean Brock	Kenansville
†**Paula Berry Frazier	Fayetteville
*Sandra Fay Futris	Fayetteville

† Co-major

* Cum Laude

** Magna Cum Laude

*** Summa Cum Laude

H Honors Program

Joseph Matthew Guthrie	Harkers Island
Holly Maria Ivey	Proctorville
*Kimberly Ann Juliano	Florham Park, NJ
*Karen Ann McLennan	Charlotte
Pamela Sue Overcash	Gastonia
Laura Terry Owen	Oak Ridge
**Malinda Jane Piland	Mebane
*Donna Lynne Shook	Advance
Evelyn Marley Smith	Greensboro
**Maria Del Carmen Viego	Wilmington
Brian Todd Wells	Mebane

Mathematics Education, Middle Grades Concentration

Degrees Conferred May 12, 1990

Bethany Jo Freeman	Raleigh
Meredyth Neil Haigler	Monroe
**Rosemarie McDowell Wilkerson	Roxboro

Middle Grades, Language Arts and Social Studies Concentration

Degree Conferred June 27, 1989

Darah Paige Harris	Raleigh
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Degrees Conferred December 19, 1989

Julia Hanna Atkinson	High Point
Julia Ann Hartwell-Ducatte	Raleigh
**Melissa Ann Isaacs	Pinnacle
Michael Allen Milligan	Washington
Sylvia Nani Swertfeger	Smithfield
Molly Lynn Ward	Advance
*Juliana Whitford	Broadway
Mark Charles Williams	Reidsville

Degrees Conferred May 12, 1990

Martha Williams Bryan	Rocky Mount
Jennifer Jane Dorman	Fayetteville

Middle Grades, Mathematics and Science Concentration

Degree To Be Conferred May 12, 1990

Leslie Yvonne Stone	Burlington
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Science Education

Degrees Conferred December 19, 1989

James Anthony Barbara, Jr.	Raleigh
Anna Demetrius Beamer	Fuquay-Varina
*Donna Katherine Boyd	Waynesville
Charles Smith Dunlop III	Brevard
*Angela Hypes Garver	Garner
Bradley Dean Hoyle	Cherryville
Kevin Dion Jones	Franklinville
†Suzanne Marie Leach	Burlington
**Louise Roth McKeand	Raleigh
Melanie Jones Williams	Oxford

Degrees Conferred May 12, 1990

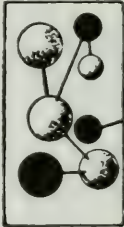
***Melissa Ann Ballington	Cary
†***Robert Kevin Blackburn	Roseboro
†Edward Clark Farr, Jr.	Charlotte
John Thomas Otstot	Raleigh
Joan Marie Reavis	Kings Mountain
†Kelan Noel Rogers	Salisbury
†**Christina Marie Whitley	Havelock
**Amy Louise Wood	Clayton
†Janet Lynn Young	Raleigh

Technical Education

Degree To Be Conferred May 12, 1990

John David Kirkley	Raleigh
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College of Engineering



BACHELOR OF SCIENCE IN BIOLOGICAL AND AGRICULTURAL ENGINEERING

Jointly administered by the College of Agriculture and Life Sciences and the College of Engineering.

Degrees Conferred June 27, 1989

Bobby Alan Cunningham	McLeansville
John Taylor Kittrell	Corapeake

Degree Conferred August 9, 1989

Maxwell Raye Fowler	Cashiers
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Degrees Conferred December 19, 1989

Michael Poindexter Dixon, Jr.	East Bend
Keith Mack Roberts	Fayetteville

Degrees Conferred May 12, 1990

*Peter James Crawford	Chapel Hill
John Dean Metcalfe	Hendersonville
Byron Glenn Moore	Nashville
*Randall Keith Page	Elon College

BACHELOR OF SCIENCE IN TEXTILE ENGINEERING

Jointly administered by the College of Textiles and the College of Engineering.

Degrees Conferred December 19, 1989

Robert Jay Bender	Fayetteville
†Stephan Max Bollinger	Spartanburg, SC

Degrees Conferred May 12, 1990

*Jinan Glasgow Bennett	Raleigh
Sherry Leslie Coonse	Granite Falls
*Nancy Marchele Evans	Wilson
Jennifer Rae Hash	Hope Mills
Brian Cletus Huss	Lincolnton
John Paul Knorr	Raleigh
Arleen Michelle McCoy	Goldsboro
John Timothy Roberts	Burlington
Robert Thomas Snyder, Jr.	Wilmington
††Jane Elizabeth Stover	Charlotte

BACHELOR OF SCIENCE IN AEROSPACE ENGINEERING

Degree Conferred June 27, 1989

**Jay Dale Hardin	Havelock
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Degree Conferred December 19, 1989

**Ian Todd Gallimore	Kannapolis
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Degrees Conferred May 12, 1990

Jeffrey Todd Antley	Cary
***John Lewis Avent	Kingstree, SC
**Robert Albert Baurle	Havelock
Kenneth Irving Beaty	Statesville
Douglas Philip Bell	Brevard
Robert Arthur Bendl	Spokane, WA
Steven Kelly Bordeaux, Jr.	Richmond, VA
***Frank Joseph Brauns	Pleasant Garden
Inho Edward Choi	Greensboro
Kevin Alan Conner	Hendersonville
Glen Patrick Doggett	Raleigh
Glynn Edward Fouche III	Greensboro
Nathan Micah Gittner	Charlotte
***David Bryan Hash	Boone
Thomas Marshall Hedrick	Thomasville
**Alan Douglas Hoffler	Titusville, FL
Christopher Scott Holder	Aberdeen
Kevin Scott Ingram	Kings Mountain
*Randell Allen Ketchie	Statesville
**Michelle Nickerson Laur	Raleigh
*Joseph Wayne Lockwood	Orlando, FL
Norman David Merritt	Roanoke Rapids
***William Edward Milholen II	Asheville
*Mark Allen Morris	Durham
Phi-Dung Hoang Nguyen	Charlotte
*Gregory Warren Page	Lake Elsinore, CA
**Joel Eric Pierce	Canadaigua, NY
Hughart Osworth Clayton Roberts	Charlotte

*Theodore Scott Ruta	Titusville, FL
Ashley Drew Salter	Jacksonville
*Drew Crawford Smith, Jr.	York, PA
**Rebecca Lynne Squires	Greensboro
*Wade Allan Stone	Baker, OR
*Michael David Todd	Burke, VA
**Terry Wayne Young	Leland

BACHELOR OF SCIENCE IN CHEMICAL ENGINEERING

Degrees Conferred June 27, 1989

†Andrew Bernhard Gloster	Greensboro
***Christopher Andrew Mastro	Chester, VA
Scott David Siegel	Jamestown
†William Scott Troutman	Florence, SC

Degree Conferred August 9, 1989

Maresa Thompson Williamson	Eureka
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Degrees Conferred December 19, 1989

Angela Faye Bagley	Dudley
**Johan Bo Bergenholtz	Raleigh
Robert Wade Harris	Vidor, TX
Gregory Bryant Hinnant	Kenly
William Edward Knighten	Rose Hill
Michael James Ledford	Canton
Monica Diane Little	Charlotte
**Barbara Ann Ludwig	Tell City, IN
*Debra Jean Massey	Roanoke Rapids
†Thomas Richard Olsen	Wilmington, DE
Derek Scott Owens	Gloucester, VA
Tuan Thanh Phan	Fayetteville
Jack Leonard Robinson	Elkin
†Andrew Robert Romano	Greensboro
William Steven Serletis	Houston, TX
Edward Thomas Sharpe, Jr.	Fountain
Renee Steelman	Kernersville
Timothy Kadez Wilde	Brevard
*James Michael York	High Point

Degrees Conferred May 12, 1990

†Matthew Wilson Barbour	Raleigh
*Carol Lynn Barnes	Kinston
Kutota B. Basisa	Kinshasa, Zaire
Alana Daryl Beard	Fayetteville
Allyson Blaney Bell	Manteo
*Timothy Aaron Boone	Marion
*Thomas Eric Brna	Cary
Carolyn Ann Bruce	Wilmington
Martha Anne Buchanan	Rockville, MD
***Kathleen Elise Cannon	Centreville, VA
**Teresa Lynette Cheek	Burlington
*Roy Lawrence Cox	Kinston
*Cynthia Paige Dawson	Kinston
Herbert Taylor Dixon, Jr.	Eure
**Jeffrey Raymond Dugas	Charlotte
**Betty Lou Gatano	Henderson
Kevin Aronhalt Hallstrom	Huntington Beach, CA

† Co-major * Cum Laude ** Magna Cum Laude *** Summa Cum Laude H Honors Program

†***Scott Alexander Hamilton	Clyde
George Julius Joncas	Rockingham
Christopher Thomas Kochanowicz	Southmont
Karen Jane Leadbetter	Chapel Hill
***Hazel Benton Matthews III	Durham
*John Thomas McLean	Denver
Amanda Gayle Monroe	Trinity
†Heidi Lyn Musser	Clifton Forge, VA
Nancy Jane Neely	Telford, PA
Pamela Norene Orr	Charlotte
*Christian Popa	Raleigh
Brian Douglas Potter	Indianapolis, IN
*Miriam Graham Preston	Winston-Salem
†Thomas Dieter Rathke	Charlotte
John Edward Reardon III	Salisbury
***Bedie Marie Roberts	Tarboro
***Mark Harold Smith	Shelby
†***Steven Wayne Smith	Waynesville
*David Eugene Thompson	Cary
†**Ronald Bowman Tucker	Browns Summit
**Joost Frans Van Haaren	Raleigh
*James Thomas Weidner	Wilmington
**Michelle Marie White	Durham
*Mark Hanson Wollum	Raleigh

BACHELOR OF SCIENCE IN CIVIL ENGINEERING

Degrees Conferred June 27, 1989

James Franklin Croom	Kinston
*Barbara Allen Doll	Currituck County
Paul Norman Hansen	Monroe, CT
Christian Todd Ray	Raleigh
Mark Lantz Reep	Kings Mountain
**Alicia Elizabeth Speight	Greenville
Theresa Ann Turner	Hillsborough

Degrees Conferred August 9, 1989

David Ross Loutzenheiser	Morris Plains, NJ
*Michael William Wolz	Wilmington

Degrees Conferred December 19, 1989

Joseph Walter Bailey, Jr.	Wilson
Mitchell Thomas Bowyer	Whitsett
Lloyd DeWayne Brown	Leicester
James Scott Cole	Charlotte
*Christopher Gray Creed	Dunn
Kimberly Jace Drew	Whiteville
***Margaret Patricia Fels	Raleigh
Frank Fitzler Fleming	Manson
Gregory Raymond Follmer	Charlotte
Carmelo Gibilaro	Burlington
Todd Allan Graham	Cleveland
Philip Sousa Harris III	Washington
Ronald Perkins Hendricks, Jr.	Edenton
Kevin Eugene Herring	Monroe
William MacArthur Hines, Jr.	Rocky Mount
Derek Arthur Hodgin	Chelsea, MI
Paul Wayne Hungerford, Jr.	Wilmington

†Co-major *Cum Laude **Magna Cum Laude ***Summa Cum Laude H Honors Program

Paul Robert Koch	Oak Ridge, TN
Paul Anthony Lampley	Cary
Edward Franklin Lewis	Randleman
Michael Charles McPherson	Raleigh
Jerry Wayne Moorefield	Sandy Ridge
Charles William Moyers	Spring Lake
Michael Dalton Patterson	Lexington
Thomas Gordon Payne	Madison
Mary Frances Poteet	Morganton
Kenneth Ray Riggsbee II	Chapel Hill
Philip Roger Schwab	Rockingham
*Trent Coleman Sherrill	Winston-Salem
Myron Christopher Spainhour	Raleigh
Marie Lessell Umphlett	Washington
Huong Van Vu	Raleigh
Kenneth Lee Wrenn	Roxboro

Degrees Conferred May 12, 1990

Christa Lynn Atkins	Greensboro
John Riddick Barber	Roanoke Rapids
Donald Reyes Bennett	Four Oaks
Kevin William Bisby	Raleigh
Timothy Michael Boland	Charlotte
Haywood Daniel Bowden	Benson
John Lance Covington	Pilot Mountain
Gregory Wayne Cox	Kinston
Robert Bonniwell Deal III	Winston-Salem
Kevin Dillahunt	Fayetteville
Barry Bryan Edwards	Raleigh
John Franklin Fishburne	Charlotte
André Raymond Fontiane	Oakton, VA
Matthew Day Foster	Cary
JoAnn Claire Giglio	Albemarle
Tyson Alexander Graves	Charlotte
William Lacy Haas	Mount Airy
Gretchen Ann Hobbs	Hobbsville
*Shannon Michelle Miller Houston	Cary
*Carl Clinkscales Huddle	New Bern
**Theresa Ann Hurban	Fayetteville
Jonathan Paul Ingram	Greensboro
Wanda Melvin James	Wilmington
Peter Guthrie Jernigan, Jr.	Fayetteville
Charles Astor Johnson III	Nashville
James Timothy Jordan	Charlotte
Gregory Andrew Kempf	Raleigh
John Brown Kimberly IV	Greenville
Shannon Lee Lasater	Burlington
Darrell Delaney Leonard	Rocky Mount
Timothy Maxton Little	Kenly
**James Allan Lowe	Batavia, NY
**Frances Elaine Manning	Raleigh
Laura Lyn Mathias	Matthews
Leo Thomas Mazzocchi	Cary
Eric Braswell Nelson, Jr.	Morehead City
John Frederick Oerter	Kernersville
Anna Currin Pennisi	Raleigh
James David Rogers	Raleigh
Thomas William Rose	Charlotte
John William Rouse	Grifton

† Co-major

* Cum Laude

** Magna Cum Laude

*** Summa Cum Laude

H Honors Program

Jeffrey Lee Sasser	Durham
Cynthia Ann Satterwhite	Winston-Salem
Brian Keith Skinner	Wilson
William Taft Stephens, Jr.	Fayetteville
Scott Ashley Stevens	Cary
Michael Glenn Taylor	Beaufort
Kumar Ambelal Trivedi	Raleigh
James Christian Turley	Greensboro
** William Herbert Turner, Jr.	Charlotte
Nathan Alan Vannoy	Lenoir
Bobby Lee Walston	Tarboro
Amy Lynne Watters	Charlotte
Gerald Martin Wynn, Jr.	Sanford

BACHELOR OF SCIENCE IN CIVIL ENGINEERING— CONSTRUCTION OPTION

Degrees Conferred August 9, 1989

Dan Daley Beauchamp	Garner
John Arthur Dilworth	Greensboro
Jeffrey Lee Herron	Whittier
Julius Brown Kachmer	Raleigh

Degrees Conferred December 19, 1989

Brian Martin Alligood	Plymouth
David Walton Bass	Lucama
Joseph Randall Carraway	Farmville
Donald Thomas Childrey	Burlington
Randall Corey Dishmon	Eden
Jon Christopher Ford	Raleigh
Joseph Randall Hopkins	Eden
Oral Lee McGirt	Fayetteville
Steven Thomas McGugan	Durham
*** Scott Ernest Rushing	Monroe
Charles Adrian Schoonover	Cape Carteret
Marc Thomas Shown	Winston-Salem
Darrow Mitchell Smith	Norwood
Anthony Dean Tyndall	New Bern
Jerry Glenwood Whittington, Jr.	Raleigh
Richard Kevin Williams	Raleigh
** Kelly Wayne Winkler	Hudson
Richard Henry Wyatt II	Newton

Degrees Conferred May 12, 1990

David Baxter Black	Lexington
Roney Bryant Bunn III	Wilson
Donal Kevin Dennis	Burlington
Barry Todd Greeson	Thomasville
Troy Richard Huddle	Shallotte
Donald Grey Lloyd, Jr.	Raleigh
Ronald Joe Long, Jr.	Gastonia
** Lowell Dean Mason II	Grestview, FL
Veronica Sirlethia McGriff	Charlotte
Kirk William Rightmyer	Roanoke Rapids
David Joseph Seneres	Garner
Paul Alexander Stimpson	Pfafftown
Jonathan Scott Thompson	Goldsboro

† Co-major

* Cum Laude

** Magna Cum Laude

*** Summa Cum Laude

H Honors Program

Spencer Drew Walker	Mill Springs
Jón Marc Wallace	Zebulon

BACHELOR OF SCIENCE IN COMPUTER ENGINEERING

Degrees Conferred June 27, 1989

Marvin Joseph Matthews	Kittrell
James Aubrey Savage III	Raleigh

Degrees Conferred August 9, 1989

Eric Ernest Edwards	Apex
†Karen Alice Holland	Cary
*Robert Edward Jeter, Jr.	Asheville
Norman Longson Nguyen	Charlotte

Degrees Conferred December 19, 1989

Michael Jerome Batts	Tarboro
Scott Eoae Blair	Lenoir
†*Tuan Quang Le	Greensboro
†Curt Steven McVey	Graham
†*Edward Louis Ostrosky	Fairfax, VA
Thomas Bertil Remahl	Charlotte
†Inder Kumar Sharma	Dekalb, IL
Mark James Walker	Charlotte
†Daren Kirby Williams	Pfafftown
***Sue Oi Yee	New Bern
James Arnold Young	Cary

Degrees Conferred May 12, 1990

Carl Anthony Bartz	Raleigh
Scott Robert Brown	Asheboro
Donna Elizabeth Carter	Charlotte
George McArthur Clubb II	Bessemer City
†***George Eric Hague II	Wilkesboro
Claude Michael Hargrove	Fayetteville
†Kay Norbert Hill, Jr.	Lexington
*Kevin Daniel Houser	Lincolnton
†*Robert Christopher Lamb	New Bern
†***Joseph Norman Morris	Winston-Salem
†***Gary Christopher Moyer	Virginia Beach, VA
*Kimberly Adams Newnam	Cary
Quyen Bui Nguyen	Cary
Thomas Spencer Pangborn	Rockingham
Davor Antonio Pavisic	Cochabamba, Bolivia
†Paul Anthony Pavlides	Durham
Heerad Sabeti-Rahmati	Fayetteville
***Darren Arthur Shakib	Lexington, KY
†Jason Ryan Sharpe	Charlotte
John DeWayne Sims	Steelton, PA
Kevin Timothy Smith	Charlotte
†Mabel Yvette Watson	Smithfield
†**Margaret Ann Woodlief	Raleigh

BACHELOR OF SCIENCE IN COMPUTER SCIENCE

Degrees Conferred June 27, 1989

Mohammad Arshed	Eden
*Lawrence Edward Goss	Rochester, NY
*Fernando Carlos Killian	Buenos Aires, Argentina
Keith Allen Leister	Boyertown, PA
***James Eric Weller	Charlotte
Scott Lewis Wilkins	Kinston

Degrees Conferred August 9, 1989

Robert John Andersen	Cary
James Anthony Boyd	Sedalia
Walter Frederick Carlsten, Jr.	Lewes, DE
Videsaha Chhabra	Raleigh
Glenn Joseph Clingroth	Fallston, MD
Albert Benjamin Cohen	Las Vegas, NV
Robert Gray Cole	Durham
**William Andrew Cook III	Hickory
Ronald Wayne Davis	Cary
Scott Brannon Greer	Matthews
**Lyu-Dan Louise Gung	Taiwan, Republic of China
Brett Smith Hatcher	Apex
Kevin Brian Haverlock	Raleigh
Benjamin Si-Lun Lau	Hong Kong
Patsy Loraine Lohr	Lexington
**Jon Mark Mendenhall	Des Moines, IA
***Pryor Reynolds Millner V	Mooreville
Jayesh Ramesh Patel	Charlotte
*Kartik R. Patel	Franklinton
**Diane Gail Schlotfeldt	Winston-Salem
Christopher David Snipes	Staley
Tommy Michael Tillman	Carthage
Khristi Ann Tomlinson	Raleigh
†***Deanna Carol Williams	Arden

Degrees Conferred December 19, 1989

Michael Gary Anderson	Winston-Salem
William Thomas Arnette, Jr.	Raleigh
James Tobias Auslander	Baltimore, MD
Debra Marie Bailey	Chula Vista, CA
Sanjeev Banerjia	Bihar, India
Kevin Bernard Belton	Charlotte
**Lisa Helene Bloom	Havelock
Christopher Owen Bransford	Greensboro
Carol Lynne Brown	Chapel Hill
Robert C. Carlyle, Jr.	Fayetteville
Bunie Northcutt Deyo	Cary
Brian Keith Durham	Durham
Kenneth Nelson Ellis	Raleigh
William Kyle Fidler	Charlotte
Richard Jesse Galler	Raleigh
Kristen Marie Geppert	Manopac, NY
***Karen Michelle Grady	Raleigh
*Paul Frederick Greene	Swannanoa
Nancy Jacqueline Griffin	Lima, Peru
**James Mark Holt	Burlington

† Co-major

* Cum Laude

** Magna Cum Laude

*** Summa Cum Laude

H Honors Program

David Michael Hope	Raleigh
Douglas Wayne Houck	Charlotte
Michael E. Huska	Asheville
Jonathan Quay Kenney	Cary
Jonathan Lee Kerfoot	Rural Hall
Gary Steven Koontz	Winston-Salem
*Timothy Kent Lowman	Valdese
Rocky Dean McMahan	Lexington
Mark Edward Medlin	Fuquay-Varina
David Lee Motsinger	Forest City
Tom Thuong Nguyen	Greensboro
Daniel Patrick O'Connor	Raleigh
*Donald Griffin Page	Raleigh
***Bernie Paul Pearce	Selma
Alkesh B. Shah	Lumberton
Stephanie Michelle Shaw	Springfield, VA
Paul Christopher Sherman	Charlotte
*Robin Marie Sloan	Morrisville
Timothy Patrick Sullivan	Loami, IL
Binh-Minh Thi Tran	Greensboro
Scott Wilburn Turner	Knightdale
*Robert Thomas Uthe	Shelby
Henry Edward Vail, Jr.	Garner
Thad Mario Welch	Fayetteville
David Ward Whitlock	Concord
Debra Jan Willis	Vale
***Thomas Allan Wrather	Hendersonville, TN
***Helen Hopson Yokeley	Wendell
***Pamela Denise Young	Raleigh

Degrees Conferred May 12, 1990

Akram Abdulah Abboud	Damascus, Syria
***Alan Gray Bishop	Raleigh
David Mitchell Bowman	Murraysville, PA
Linda Ann Brady	Greensboro
Wen-Wen Chang Chi	Chapel Hill
Mary Michele Clatworthy	Raleigh
Margaret Evelyn Cuning	Charlotte
Fonda Jonette Daniels	Winston-Salem
***Duane Allen DeCapite	Charlotte
Malini Desai	Lusaka, Zambia, Africa
*John Horton Dowdy, Jr.	Middlesex
Carl Addison Ely	Winston-Salem
**Timothy Earl Figgins	Raleigh
***Jeffrey Alan Glasser	Raleigh
**James Russell Godwin	Rocky Mount
Jeffrey Neal Godwin	High Point
Peter Thomas Goeller	Raleigh
Norman Bo Graham	Raleigh
*Beth Renee Gunderson	Raleigh
†**Stephen David Hench	Raleigh
Stacy Alise Hilliard	Baltimore, MD
**Laura Dawson Hocutt	Raleigh
Debora Frisbee Houck	Raleigh
*Denise Jane Ingram	Greensboro
*Janet Kimberly Kilgore	Cary
***Timothy Marshall Klein	Wilmington
Cynthia Marie Knowles	Raleigh

† Co-major

* Cum Laude

** Magna Cum Laude

*** Summa Cum Laude

H Honors Program

Gerrit Jon vanWeerden Koetse	Yorktown Heights, NY
Janet Meryl Leake	Cary
John Jake Lomick, Jr.	Bessemer City
Rodney Len Longworth	Winston-Salem
John Rayvon Lucas, Jr.	Albemarle
Deborah Ann Mack	Cary
Bernard Joseph Moussa	Beirut, Lebanon
Candace Lura Olive	Apex
*Kenneth James Parzygnat	Raleigh
***Brian Keith Pearce	Durham
Mette Marie Pederson	Raleigh
Basil Shukri Qubain	Raleigh
**Rodney Ray Rymer	China Grove
James Christopher Saunders	Newark, DE
Douglas Michael Seay	Cary
Todd Gunter Sorrell	Benson
Rama Devi Tenjarla	Raleigh
Hsiu-chi Tsui	Charlotte
Joseph McClain Tyson	Havelock
Michael Stanley Woods	Catawba

BACHELOR OF SCIENCE IN CONSTRUCTION MANAGEMENT

Degree Conferred December 19, 1989

Sheila Monique Wright	Brown Summit
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Degree Conferred May 12, 1990

Richard Taylor Puckett, Jr.	Oxford
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BACHELOR OF SCIENCE IN ELECTRICAL ENGINEERING

Degrees Conferred June 27, 1989

*Hal Anthony Aldridge	Garner
Gregory Rodolph Gibbs	High Point
**Quy Ngoc Hoang	New Orleans, LA
**Terese Anne Marsico	Cary
William Harford Quaintance III	Raleigh
Eric Keith Rookard	Fairforest, SC
Julius Edward Stegall	Oxford

Degrees Conferred August 9, 1989

Fred Alexander, Jr.	Charlotte
†Christopher Walon Apple	Greensboro
Howard Ray Beasley	Benson
Bryan Scott Butler	Charlotte
Daniel Timothy Cockerill	Asheboro
Kimberly Lynn Jones	Candler
Chiu-Hsiung Kao	Taipei, Taiwan
Mark Boyd Kissel	Fuquay-Varina
John Andrew Morehart	Rocky Mount
†Norman Longson Nguyen	Charlotte
Quyen Bui Nguyen	Cary
Suthichai Sing Nolpho	Portsmouth, NH
Michael Dexter Reid	Myrtle Beach, SC
Wayne Joseph Rosa	Salisbury
Warren Ashley Sears	Greensboro
Jeannette Beatrice Smith	Raleigh

William McKinley Staggs, Jr.	Shelby
Charla Diane Stirewalt	Weaverville
†***Deanna Carol Williams	Arden

Degrees Conferred December 19, 1989

***Michael Eugene Bailey	Salisbury
Gurth Christopher Baron	Waynesville
Brent William Blunden	Chapel Hill
Dwayne Dale Bost	Hampstead, MD
*William Creed Boyce	Charlotte
*Kevin Pershing Braswell	Smithfield
***Randall Glenn Bright	Sanford
Gregory Howard Brynildsen	Durham
William Adrian Buie, Jr.	Garner
Tariq Khan Burki	Durham
*Warren Stephen Burnside	Belfast, North Ireland
Ronald Rock Caplette	Hickory
Ross Allen Carevic	West Chester, PA
Steven Ray Carr	Greensboro
Orlando Yves Carter	Stedman
Rituraj Chauhan	Richmond, VA
Anthony O'Neil Copeland	Warrenton
**Michael Brian Creech	Concord
Dennis Edward Daily	Hagerstown, MD
Gary Shawn Daniels	Wilmington
Charles Donald Davis, Jr.	Pickens, SC
*Rodney Scott Daw	Goldsboro
*Michael Paul Dean	Ellicott City, MD
Nelson Eggleston	Marquette, IA
**James Paul Eno	Warwick, RI
†*Carlos Enrique Farrington	Guatemala, Guatemala
Wesley Dean Faulkner	Charlotte
Jay Alexander Felker	Winston-Salem
William Michael Geer	Charlotte
James Everett Gill	Charlotte
*Michael Troy Gurkin	Winston-Salem
Elizabeth Ann Gwyn	Wilmington, DE
Kurt Alan Habecker	Memphis, TN
Joseph Tracy Hester	Kernersville
Naji Mahmoud Hilal	Kornayel, Lebanon
Daniel Joseph Hogan III	Edenton
Karen Alice Holland	Cary
*Mark Len Howard	Salisbury
Thao Cong Huynh	Charlotte
Brian Robert Klapchar	Raleigh
David Alvan Krause	Greensboro
Abdullah Omar Labbad	Raleigh
Gary Michael LaFleur	Charlotte
Keith Wayne Landreth	Winston-Salem
†*Tuan Quang Le	Greensboro
Chien-Wei Lee	Taiwan, Republic of China
Lian Toh Lee	Senjarom, Malaysia
Michael Joseph Lewis	Leland
Christopher Stephen Locklear	Pembroke
Harold Michael Long, Jr.	Tarboro
Clint Monroe Lowry	Pembroke
Robert Scott Marchant	Ellicott City, MD
Lynwood Gilmore McCoy, Jr.	New Bern
†Curt Steven McVey	Graham

† Co-major * Cum Laude ** Magna Cum Laude *** Summa Cum Laude H Honors Program

*James Erskine Mitchell, Jr.	Stanley
Milton Thomas Mooring, Jr.	Snow Hill
Tori Marie Morhard	Elizabeth City
Kenneth Ray Moss, Jr.	Whiteville
Thanh-Binh Ngoc Nguyen	Harrisburg
Berjoe Simplina Occena	Windsor
†*Edward Louis Ostrosky	Fairfax, VA
Walter George Pelkey	Norfolk, NY
Jay Edward Polo	Big Flats, NY
Jeffery Allan Priddy	High Point
Mouli Raman	Raleigh
*Christopher Scott Reid	Endwell, NY
John Charles Rinehart	Dunkirk, MD
Michael Scott Rooney	Wallingford, CT
Ali Soheil Sadri	Tehran, Iran
Thomas Alex Scotton	Staley
**Maryam Shamsjosdany	Isfahan, Iran
*Steven Frances Shannon	Wake Forest
†Inder Kumar Sharma	Dewalb, IL
Donald Gene Sharpe	Rocky Mount
Jeffrey Mark Shaver	Concord
Nancy Catherine Shaw	Mount Olive
Simon Honman Sin	Hong Kong
Francis Edward Skinner	Candler
Paul Vincent Steininger	Asheville
Denis Gynorris Suggs	Kinston
Ali Asghar Tarighatjoo	Kerman, Iran
*William Terry Tidwell	Augusta, GA
Nikita Kumari Vyas	Raleigh
Michael Theodore Waters	Raleigh
Dennis Charles Wilkerson	Salisbury
†Daren Kirby Williams	Pfafftown
Fredrick Albert Woolard	Canoga Park, CA
Paul Mark Yanik	Asheville
Neil Woody Yeargin, Jr.	Dunn
*Yousef Mohamad Zaatar	Leicester

Degrees Conferred May 12, 1990

Tuhina Aggarwal	Cary
Donald Roger Aldridge	Shaw AFB, SC
Owen Mark Allen	Wilmington
*Scott Frederick Andrus	Hendersonville
Derek Durrell Ballard	Pfafftown
Elizabeth Beauchamps	Miami Lakes, FL
*William Carlyle Beerman	Charlotte
**Mikeal Scott Bolick	Winston-Salem
**Karim Samy Mina Boutros	Alexandria, Egypt
**Michael James Brack	Kingston, NY
Douglas Wayne Brott	Asheville
*Donna Lynn Brown	Washington
Matthew David Burleson	Barnardsville
*Patsy Yvonne Cannon	High Point
***Daniel Walter Carlson	Raleigh
David Hudson Carter	Burlington
Yogesh Trikam Chavda	Manama, Bahrain
**Audrey Don Chavis	Pembroke
*Philip Dean Chelf	Fayetteville
Donald James Clark	Horseheads, NY
**Anthony Ray Cockerham	Rural Hall

† Co-major

* Cum Laude

** Magna Cum Laude

*** Summa Cum Laude

H Honors Program

**James Robert Crenshaw, Jr.	Wilmington
Ronald Francis Curl	Mebane
**Joseph Carl Davis	Newport
***Wynand Crawford DePuy	Charlotte
Van George Diatzikis	Concord
Michael Sean Doggett	Raleigh
Randell Coye Durham	Clayton
†***David Brian Eason	Durham
**Mark Alan Enyedi	Kinston
***William James Farlow	Sophia
Paul Edward Fetzter	Morehead City
Shawn O Flynn	Midway Park
**Eric Stafford Grant	Burlington
*David Allen Guthrie	Kinston
Jonathan Hyang-Su Ha	Fayetteville
Thomas Mark Hadley, Jr.	Raleigh
†***George Eric Hague II	Wilkesboro
Damon Bernard Harley	Fayetteville
***Reid Vick Harris III	Seaboard
Brandon Lyle Hill	Trinity
**Edward Barry Hill	Charlotte
†Kay Norbert Hill, Jr.	Lexington
Charlton Richard Hirsch	Philadelphia, PA
***David James Holcombe	Raleigh
**David Michael Houck	Raleigh
Sonetra Anne Howard	Waynesville
Julie Lynn Jenkins	Charlotte
Paula Kay Jimison	Charlotte
Gary Lee Jones	Asheville
Linda Mable Kershaw	Raleigh
Robinder Singh Koura	Leeds, England, U.K.
†*Robert Christopher Lamb	New Bern
Dale Richard Larocque	Saint Johnsbury, VT
Darrell Ray Laughinghouse	Hookerton
*Wai-Yee Daniel Leong	Singapore
Steven Eric Lisowe	Raleigh
Yuh Liu	Kaohsiung, Taiwan
**David William Lucas II	Charlotte
Steven John Macko	Raleigh
Nader Mansouri	Charlotte
Roger Daren Matthews	Louisburg
Scott Eugene McCollum	Yadkinville
Paul Matthew McNeary	Shelby
*David Anthony McRee	Charlotte
Michelle Lynn Mills	Greensboro
Stuart Gray Mills	Lumberton
William Jean Minton	Raleigh
*David Jefferson Mitchell	Raleigh
Ayub Mohammed	Dhaka, Bangladesh
Jonathan Edward Moon	Silver Spring, MD
Thomas Carlton Moore	Hillsborough
†***Joseph Norman Morris	Winston-Salem
*John Bryan Morton	Jacksonville
*Zebulon Vance Moseley III	Kinston
†***Gary Christopher Moyer	Virginia Beach, VA
**James Lewis Nance	Wilmington
Laurie Anne Newkirk	Raleigh
†*Joseph Asiano Nguyen	Greensboro
Uyen Ly Nguyen	Raleigh

† Co-major * Cum Laude ** Magna Cum Laude *** Summa Cum Laude H Honors Program

**Anthony Jackson Norris	Morehead City
†Paul Anthony Pavlides	Durham
William Jackie Pearce, Jr.	Asheboro
Richard Henry Perkins	Raleigh
Shahram Peykamian	Isfahan, Iran
**Celia Johnson Pfautz	Goldsboro
*Hien Quang Pham	Charlotte
David Christopher Plentovich	High Point
*Geoffrey Frank Purvis	Kernersville
*John William Purvis III	Rocky Mount
*Eric Luther Reese	Lenoir
William Kelvin Rogers	Brevard
Christopher W Ryan	Burlington
***Camil Farah Samaha	Raleigh
*Richard Henderson Scales	Winston-Salem
Jeffrey David Schachte	Simsbury, CT
Craig Steven Scruggs	Mooresboro
†Jason Ryan Sharpe	Charlotte
Jewel Renee Sharpe	Rocky Mount
Kenneth Shepherd	Fayetteville
Dhanaraj Shunmugam	Singapore, Singapore
Charles Christopher Siehl	Raleigh
Leonard Mann Slack III	Raleigh
James Glen Smith	Sparta
Madison Campbell Steadman	Wrightsville Beach
Christopher Alan Stegall	Marshville
Teva Jane Stone	Wilmington
**Matthew Bruce Tichenor	Raleigh
Howyda Kamal Toma	Cary
Christopher Brent Turner	Erwin
Stephen Max Tussey	Concord
*Todd Edward Wagoner	Snow Camp
*Stanley Jefferson Wall	Fuquay-Varina
†Mabel Yvette Watson	Smithfield
*Anthony Todd Wells	Rustburg, VA
**Allison Janeen Wesley	Jackson
Scott Anderson Woodall	McLeansville
†**Margaret Ann Woodlief	Raleigh
***Sui Oi Yee	New Bern
Randy Scott Young	Raleigh

BACHELOR OF SCIENCE IN FURNITURE MANUFACTURING AND MANAGEMENT

Degrees Conferred June 27, 1989

†Foong-Ha Lo	Seremban NS, Malaysia
Mark Andrew Meyer	Morganton

Degrees Conferred December 19, 1989

Kevin Wayne Hefner	Sherrills Ford
Jeffrey Crowson Hunt	Thomasville
Thomas Hart Kemp	Dudley
James D. Yau	Wrentham, MA

Degrees Conferred May 12, 1990

Stephen Andrew Alston	Tarboro
Lawrence Frederick Cheatham III	Sanford
John David Vaughan	Galax, VA

† Co-major * Cum Laude ** Magna Cum Laude *** Summa Cum Laude H Honors Program

BACHELOR OF SCIENCE IN INDUSTRIAL ENGINEERING

Degrees Conferred June 27, 1989

Leslie Sue Andrews	Roxboro
**Tony Jackson Blevins	Crumpler
Joseph George Cesari, Jr.	Ashland, PA
**Christopher Anthony Dockery	Asheville
Becky Mohap Futrell	Virginia Beach, VA
Margaret Elizabeth Griffiths	Pittsburgh, PA
*Ricky John Hollodick	Cary
Robert David Kemper	Nags Head
Kathryn Marie Kienast	Davidsonville, MD
†Foong-Ha Lo	Seremban NS, Malaysia
Charles Grant Oakley, Jr.	Graham
Danyna Andrea Patterson	Durham
Phillip Delano Simpson	Raleigh
Danny Neal Sims	Southern Pines
**Randall Todd Stokes	Raleigh
Curtis Lee Tilly	Charlotte
Randy Dennis Williams	Wilmington
**Stephen Mark Wimmer	Charlotte
Lelon Worth Winstead, Jr.	Bunn

Degrees Conferred August 9, 1989

John Scott Daniel	Williamston
Andrea Jane Filo	Raleigh
Richard Thomas Hayes V	Wilmington
*Richard Gary Paxton, Jr.	Annandale, VA
Annie Gia Pham	Cary
Michelle Gay Smith	Havelock
***Sevi Gunal Ulubay	Turkey

Degrees Conferred December 19, 1989

David Alan Adelman	Raleigh
James Douglas Anderson	Raleigh
*Paula Georgette Boulware	Iron Station
**Emily Harding Brown	Burke, VA
Charles Edward Canrobert	Conover
Ian Vincent Chase	Southern Pines
Pamela Arleen Cozart	Garner
Suit Gan Davis	Sungai Jarom, Malaysia
Susan Lee Dunbar	Raleigh
Matthew Charles Fisher	Raleigh
Andrew Carroll Fox	Charlotte
Joseph Charles Gravalec	Stratford, CT
Stacey Deal Gross	Greensboro
Todd Allen Hudson	Winterville
**John Chae Kim	Archdale
Jeffrey Todd Lammert	Danbury, CT
Eileen Marie Leahy	Ellicott City, MD
Ruth Ann Miesse	Raleigh
Amy Elizabeth Moore	Wilmington
Jeffrey Glenn Moore	Walstonburg
Joseph Stanfield Nicks	Mebane
Jamie Ann Marie Nile	Morristown, NJ
Kenneth Edwin Noll	Cincinnati, OH
Richard Earl Perryman, Jr.	Thomasville
*Karen Jean Purer	Lynn Haven, FL

† Co-major

* Cum Laude

** Magna Cum Laude

*** Summa Cum Laude

H Honors Program

Michael Alan Roberts	Lincolnton
James Washington Self, Jr.	Bluthewood, SC
Elizabeth Marie Shealy	Hendersonville
Charles Garrett Walker III	Goldsboro

Degrees Conferred May 12, 1990

**Janet Marie Ange	Cary
*Richard Lawrence Auerweck	Southampton, PA
**Tabatha Cox Barbour	Benson
Christopher Lee Baucom	Southern Pines
Scott Milton Benfield	Lenoir
Stephen Michael Blair	Lenoir
Kimberly Marie Blalock	Timberlake
Andrew Melton Bridgeman	Southern Pines
Henry Joseph Burkard	Greensboro
Erica Lynne Craft	Fayetteville
Michael Calvin Crusenberry	Raleigh
William Allen Curlee III	Martinsville, VA
Matthew Roland Dionne	Martinsville, VA
Richard Alan Drummond	Laurinburg
Elizabeth Leigh Frank	Hickory
Margaret Lynn Frank	Hickory
Kimberly Gale Goff	Wilson
***Marion Susanne Hackney	Washington
Margaret Saunders Haga	Jacksonville
Karen Ada Hudson	Turkey
*Tamara Leigh Hudson	Greensboro
**Tamara Yvette Jackson	Randallstown, MD
*Julia Marie Kinane	Raleigh
**Bryan Dampier King	Farmville
George Edward King, Jr.	Greensboro
Wael Rifat Masri	Mreijat, Lebanon
Constance Dawn Mayhew	Shelby
***Lynn Marie McGoogan	Elon College
Richard Scott McKenzie	Raleigh
*Mary Michelle Mills	Wake Forest
***Kimberly Ann Monroe	Wadsworth, OH
***Anthony Willard Payne	Marshall
*Jimmy Dale Pippin	Mount Airy
Allison Rochelle Respass	Fort Smith, AK
Carlos German Sequeira	Granada, Nicaragua
Nader Badri Shahin	Nablu, West Bank Jordan
Alea Ann Spaulding	Vass
*Wendy Gayle Stephenson	Willow Spring
Kathryn Elizabeth Talacek	Clayton
Daniel Giles Talbot	Islip, NY
Daryl Tim Traywick	Marshville
James Andrew Valentine	Andover, NJ
**Wendy Ann Wahab	Cary
Marshall Thomas Watkins, Jr.	Raleigh
Lisa Cornelia Wells	Wilson
Bradley Otto Willett	Greensboro
Deanna Lynn Wray	Fayetteville
Harry Robert Yauger III	Cameron

BACHELOR OF SCIENCE IN MATERIALS SCIENCE AND ENGINEERING

Degrees Conferred June 27, 1989

Thomas Nelson Ackerson	Palatine, IL
Ricardo Velasquez	Goldsboro

Degree Conferred August 9, 1989

*Thomas Eric Skidmore	Marion
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Degrees Conferred December 19, 1989

David Thomas Chapman	Raleigh
Michelle Ann Hoyt	Durham
*Mina Louise McKay	Morehead City
Patricia Ann Peterson	Cary
Scott Robert Sahaida	Raleigh
*Christopher William Widenhouse	Wilmington

Degrees Conferred May 12, 1990

Todd Lee Barbee	Albemarle
***David William Bray	Reidsville
Martha Elizabeth Emory	Wilmington
Karen Jean Freeman	Charlotte
Joseph Patrick Halloran	Erie, PA
**Vincent Harold Hammond	Bogart, GA
Robert Matthew Overby	Reidsville
Brett Nixon Pulliam	Athens, GA
Cameron Edwin Shearon, Jr.	Raleigh
John Michael Streitman	Charlotte
***Warren Andrew Thomas	Arlington, TX
David Brian Zybko	Lexington, VA

BACHELOR OF SCIENCE IN MECHANICAL ENGINEERING

Degrees Conferred June 27, 1989

*Wallace Adamson	Brownsville, PA
Jonathan Yost Alligood	Concord
Richard Jesse Galler	Raleigh
Todd Edwin Harriman	Clemmons
Cleveland Craddock Kern III	Wilton, CT
Aloysius King	Greenville
Charles Moseley Lowe	Raleigh
Christian Louis Pecci	Raleigh
Dale Alan Pressley	Horse Shoe
David Lee Pressley	Horse Shoe
Henry Frederick Schwetcke	Jacksonville
Douglas Gregory Stewart	Derwood, MD
Harold Jeffery Suggs	Nakina
Travis Lee Winn	Creedmoor

Degrees Conferred August 9, 1989

Anthony Dean Ballance	Fremont
Wayne Andy Beaver	Murphy
*Michael Thomas Collins	Raleigh
Omar Abdel-Hadi Essader	Raleigh
***David Adam Gerson	Raleigh
Jerry Wayne Gordon	Raleigh

† Co-major

* Cum Laude

** Magna Cum Laude

*** Summa Cum Laude

H Honors Program

*Brian Lee JohaneK	Charlotte
**David Joe Kendell	Sterling, IL
John Wells Logan III	Wilmington
Joseph Alan Morgan	Charlotte
Michael Art Neas	Temple Hills, MD
Matthew Robert Rankin	Charlotte
Michael Kreg Sheppard	Hendersonville
Earl Michael Zimmerman	Millville, NJ

Degrees Conferred December 19, 1989

Robert Joseph Ackley, Jr.	Matthews
Thomas Brett Allen	Charlotte
David Orren Babcock	Ayden
David Kirk Bailey	Newport
Robert Spence Bass	Nashville
Anthony Wayne Blackman	Raleigh
Linda Myers Chaplin	Raleigh
John Barry Chappell	Butner
Richard Alan Coe	Emerald Isle
**Donald Arthur Comire	Charlotte
Charles Kenneth Cutts III	Charlotte
**Joel Thomas Denning	Faison
†*Carlos Enrique Farrington	Guatemala, Guatemala
**Grant Jason Fish	Willow Spring
Carl Melchior Fisher, Jr.	Charlotte
Christopher Earl Foust	Asheville
Karl David Freeman	Fayetteville
William Lee Fritts	Mount Gilead
***Linda Adrienne Frye	Hickory
Tracy Hilton Frye	Statesville
Stephen Ryan Futrell	Charlotte
Hugh Patrick Gaines	Gastonia
**Robert Frederick Gansman	Charlotte
John Timothy Griffin	Fayetteville
Michael Todd Hines	Four Oaks
*Avinash Kumar Jalan	Dhanbad, India
Tracy Anderson Jones	Charlotte
Larry Richard Lane	Wilmington
Troy David Lenderking	Raleigh
***Ronald Gerald Lindsay, Jr.	Raleigh
***Mary Elizabeth McKnight	Oriental
Keith Anthony Moore	Ellenboro
Darren Christopher Morton	China Grove
Mark John Mulder	Riveredge, NJ
John Michael Nelson	Wilmington
Robert Andrew Owens	Hillsborough
Phillip Sherrill Parsons	Troy
David Scott Payne	Marshall
**Walter Brent Pressley	Landis
**Carol Reynolds Purvis	Asheboro
*Bradley Trent Queen	Columbia, SC
*Michael Thomas Queen	Silver Spring, MD
***Jeffrey Scot Ricks	Elizabeth City
Larry Craig Roberson, Jr.	Garner
**Bart Ethan Schichtel	West Redding, CT
David Edward Shepherd	Hendersonville
Abd-Halim Shuib	Telak Intan, Malaysia
Gary Allan Shuler	Jamestown

Sean McLaughlin Smith	Raleigh
Philip Mercer Stanford	Concord
Sean Paul Stapf	Canton
Christina Michele Stephenson	Flat Rock
Joe Hiep Swindler	Greensboro
*Kenneth Darrell Temple, Jr.	Asheboro
Richard Allen Tucker	Kinston
Bruce Carrow Watson, Jr.	Washington
Brian Keith Wilshire	Cary
Michelle Winfield	Monroe
Thomas Preston Winslow, Jr.	Wilmington
Daniel Wittels	Durham
Patrick Isom Woody	Charlotte
*Andrew Paul Yanoschak	Raleigh

Degrees Conferred May 12, 1990

Ajay Kumar Anand	Sikeston, MO
David Patrick Aydtlett	Camden
Claire Hobbs Barrett	Raleigh
***Jonas Marc Batten	Lilburn, GA
**Kenneth Franklin Beasley	High Point
**Kathleen Marie Biseli	Treasure Island, FL
Roy Thomas Bivens	Jamestown
Jeffrey Kenan Blackwood	Greensboro
Stephen Murphy Boone	Lumberton
Steven Paul Bouchelle	Sanford
*Patrick Scott Brittain	Connelly Springs
Stuart Bruce Brown	Cary
Kevin Cortier Calhoun	Washington, DC
Paul Wesley Carpenter	Charlotte
*Barry Todd Cease	Hanahan, SC
Cordelia Kaye Chandler	Kinston
**Douglas George Chapman	Hickory
**Christopher Charlie Cheek	Halifax, VA
Alan Edward Clark	Morganton
Rodney Shane Connor	Cary
**John Peter Cooper	High Point
William Lee Cowan	Asheville
*Tracy Wayne Crews	Kernersville
Mark James Cuilla	Knightdale
Frederick Earl Cumbo, Jr.	Clinton
**Larry Charles Dickinson	Hickory
Anthony Nesbitt Dotson	Asheville
Lawrence Lee Dulin	Charlotte
Howard Blake Eaddy	Gastonia
Mark Edwin Earley	Leicester
Ibrahim Mohammad El-Asad	Amman, Jordan
Arik Eshal	Nahalal, Israel
***Charles Benjamin Fain	Clemmons
Robert Gray Ferree IV	Asheboro
*Jeffry Robertson Foeller	Reidsville
David Blair Galloway	Burlington
Karl Jonathan Geddes	Burgaw
Scott Lawson Goller	Greensboro
Robert Bryan Grice	Leland
Angela Yvette Griffin	Newark, DE
**Stanley Mark Gryder	Hiddenite
Mickey Jay Hall	Laurel Springs
David Lawrence Hammock	Eden

† Co-major

* Cum Laude

** Magna Cum Laude

*** Summa Cum Laude

H Honors Program

Thomas Joseph Harmon, Jr.	Low Gap
*Timothy Brett Harris	Matthews
Sam Arthur Hopkins	Walnut Cove
Stephen Wallace Howell	Raleigh
*John Michael Huffman	Winston-Salem
***Robert Daniel Irlbeck	Raleigh
Gregory Brian Jackson	Sanford
John Steven Johnson	Morrisville
Robert Charles Kantlehner	Greensboro
**Kristin Elizabeth Keidel	Muskegon, MI
George Patrick Kelley	Rural Hall
Jae Ho Kim	Burlington
Kevin Joseph Konrad	Pittsfield, MA
***Gregory Lee Krause	Charlotte
Jeffrey David Kunstling	Kinston
Avery Darren Laphish	Mocksville
James Shiuh-Tsong Lee	Charlotte
John Robin Liles IV	Littleton
**Michael Anthony Lynam	Morganton
James David Madsen	Hilton, NY
Douglas Scott May	Oriental
Keith S McAllister	Newark, DE
Patrick Joe McKee	Raleigh
Xavier Rustia Miranda	Charlotte
*David Franklin Mitchell	Asheville
Darin Lee Moore	Charlotte
Samuel Joseph Moses	Greensboro
Rayfield Mixon Neel, Jr.	Charlotte
**Joel David Nicholson	Hickory
Lori Ann Nicholson	Elizabeth City
Dennis George Nield	Concord
Dinnagy Priyanka Padmaperuma	Colombo, Sri Lanka
Keith Wayne Parise	Bryans Road, MD
Jin Woo Park	Jamestown
Leston Curtis Parks III	Wilmington, DE
Lisa Diane Pletcher	Rockville, MD
John Thomas Price	Four Oaks
**David Franklin Purvis	Bennett
Steven Boyd Putnam	Boiling Springs
Curtis Paul Queen	Catawba
***Brian James Riley	Newton
*Donald Louis Rockwell	Cary
*Mark Alan Rogers	Clinton
Thomas King Rouse, Jr.	Greensboro
Mark David Rush	Raleigh
Robert Edwin Schantz, Jr.	Fairport, NY
*Charles Wakeling Shepherd	Wilkesboro
*John Paul Sheppard II	Gastonia
Christopher Scott Shipp	Charlotte
**Patricia Lena Smith	Raleigh
**Robert Merrill Smith	Edinboro, PA
Russell Edward Smith	Waynesville
*Timothy George Smith	Clayton
Todd Douglass Smithy	Stony Point
William Scott Snow	Mount Airy
Robert James Stanley II	Raleigh
Robert Albert Skasko, Jr.	Charlotte
†**Jane Elizabeth Stover	Charlotte
Milton Scott Swindler	Swan Quarter

Scott Webster Syme	Shelby
Daryl Perry Tunstall	Raleigh
**Scott Edward Tutak	Kinston
Johnny Dean Underwood	Candler
Oswaldo Rolando Vargas	Raleigh
†Robert Allen Venezia	Cary
Dennis William Wertz, Jr.	Cary
Kenneth Allen Wetherington	New Bern
James Douglas Yates	Charlotte

BACHELOR OF SCIENCE IN NUCLEAR ENGINEERING

Degrees Conferred December 19, 1989

George Dewey Greenway, Jr.	Fayetteville
Edward Michael Jakes	Pittsboro

Degrees Conferred May 12, 1990

David Daniel Beatty	Lumberton
Jeffrey Carl Britt	Goldsboro
Christopher Allen Chrislip	Newton
Margaret Teresa Gibson	Boone
Milton Edward Gorden	Monroe
Robert George Hill	Goldsboro
*Kelly Bryan McCurry	Weaverville
**Kevin Neil Roland	Eden
John Parker Schwenker, Jr.	Lake Shawnee, NJ

College of Forest Resources



BACHELOR OF SCIENCE IN CONSERVATION

Jointly administered by the College of Agriculture and Life Sciences and the College of Forest Resources. See page 1 under the College of Agriculture and Life Sciences for a listing of the graduate seniors in the jointly administered program.

Degree Conferred June 27, 1989

Brian Antonio Ferebee	Elizabeth City
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Degree Conferred May 12, 1990

**Christopher Frank Dumas	Wilmington
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BACHELOR OF SCIENCE IN FORESTRY

Degree Conferred June 27, 1989

Robert Melton Polk III Laurinburg

Degrees Conferred August 9, 1989

Harvey Brent Reed High Point
Thomas Alexander Smith Shelby

Degrees Conferred December 19, 1989

Diana Lea Broome Salisbury
Paul Timothy Eriksson Ledgewood, NJ
Kathleen Turner Ferdon Raleigh
Rachelle Ann Peterson Asheboro
James Eugene Malpass II Delco
Victor Haynes Parrish Raleigh
William Brooks Rudd Greensboro
*Forrest Henry Teague, Jr. Goldsboro
Thomas Dale Thrash Asheville

Degrees Conferred May 12, 1990

Jeff Landon Beutel Raleigh
Barbara Ann Boothroyd Asheville
Jerold Marcellus Bryant Georgetown, SC
*Melanie Ann Burke Decatur, AL
David Vernon Dry Charlotte
Eduardo Luis Garcia San Juan, Puerto Rico
Scott Patrick Gottfried Hope Mills
Paula Annette Gray Eden
***James William Hauser Raleigh
Robert Billy Kidd Siler City
Jon Joseph Klischies Westampton, NJ
William Collicott Mann Chapel Hill
*David Bruce Powell, Jr. Franklin, VA
Mark Donovan Tippet Greensboro
Randall Frank West, Jr. Andrews
Charles Anthony Wisekal II Perry, GA

BACHELOR OF SCIENCE IN PULP AND PAPER SCIENCE AND TECHNOLOGY

Degrees Conferred June 27, 1989

Andrew Bernhard Gloster Greensboro
Angela Blair James Elizabeth City
Bryan Reid Kay Wilmington

Degrees Conferred December 19, 1989

Chavonda Janeva Jacobs Augusta, GA
George Julius Joncas Rockingham
Retha Jeanette McRae Wilmington
*Albert Keith Williams Roanoke Rapids
DeNorris Williams Nashville

Degrees Conferred May 12, 1990

†Matthew Wilson Barbour Raleigh
John Edward Chevalier Hopewell, VA

Kevin Cornell Christian	Providence Forge, VA
**Robert Shean Cumbee	Supply
**William Gregory Fullenwider	Lewisport, KY
Kevin Jerome Gramelspacher	Tell City, IN
*John William Graves	Pensacola, FL
†***Scott Alexander Hamilton	Clyde
Sylvia Ellen Kirsten	Dallas, TX
Joan Renée Lee	Seaboard
**Mitchell Alan Malcolm	Centerville, GA
**John Gerhard Michael	Warner Robins, GA
†Heidi Lyn Musser	Clifton Forge, VA
Andrea Leigh Nelson	Macon, GA
**John Charles Single	Atlanta, GA
Paulette Thomas	Jacksonville
†**Ronald Bowman Tucker	Browns Summit

BACHELOR OF SCIENCE IN RECREATION RESOURCES ADMINISTRATION

Degree Conferred August 9, 1989

Mary Beth Auld	Raleigh
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Degrees Conferred December 19, 1989

Richard Floyd Baker	Spruce Pines
Jill Michele Brooks	Kings Mountain
Jack Milton Daniels	Cary
Angeline Paulette Martin	Garysburg
David Allen Ploeger	Apex
Greg Gerard Sanders	Raleigh
Gregory Alan Rowe	Lexington
Christopher Morgan Snow	Mount Airy
*Mark Alan Woodrow	Rocky Mount
*Tonia Michelle Wells	Rosewood

Degrees Conferred May 12, 1990

***Deborah Lynn Alender	Savannah, GA
Paulette Lynn Barrett	Aurora
Anna Catherine Beam	Rutherfordton
*Margaret Mitchell Campbell	Raleigh
Paul Timothy Eriksson	Ledgewood, NJ
Gina Lynette Fuller	Selma
Todd Daniel Hogue	Raleigh
Curtis Mark Klausner	Hampton, NH
Gregory George Linker	Rockville Centre, NY
**Michelle Rodriguez	Fayetteville
Ward Graham Swann	Winston-Salem
Brett D. Williams	Tulsa, OK

BACHELOR OF SCIENCE IN WOOD SCIENCE AND TECHNOLOGY

Degree Conferred December 19, 1989

Bernard Thomas Rose	Seaboard
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Degrees Conferred May 12, 1990

Jay Dwight Borrell	Roanoke Rapids
Harold Dixon Herman, Jr.	Hickory
Gary Neil Jenkins	Gastonia
Stacy Gardner Johnson	Kinston

† Co-major

* Cum Laude

** Magna Cum Laude

*** Summa Cum Laude

H Honors Program

Gregory Richard Kasten	Edwardsville, IL
Roger Gary Poindexter	Troy
Jack Merritt Ragan III	Raleigh
James Edward Rubino	Montross, VA
***Talya Rachel Selbst	Savyon, Israel
**James Alexander Snyder	Monroe
***Reynolds Wallin Trull	Henderson

College of Humanities and Social Sciences



BACHELOR OF ARTS IN ACCOUNTING

Degrees Conferred June 27, 1989

Phillip Allen Cervi	Charlotte
Gwendolyn Beth Harris	Goldsboro
LeAnne Elizabeth Johnson	Wrightsville Beach
Lori Ann Liberty	Cary
Christine Alice MacGregor	Annapolis, MD
Walter Worsley Peel	Durham
Karen Ann Travis	Neshanic Station, NJ
Jennifer Melissa Ward	Raleigh

Degrees Conferred August 9, 1989

Jeffrey Stephen Boyd	Raleigh
Karen Elizabeth Brown	Raleigh
Richard Lee Cullum	Havelock
Katherine Louise Griffin	Fairmont
Kenneth Steven Halas	Charlotte
Michelle Patrice Huie	Silver Spring, MD
Allen Gregory Moseley	Fayetteville

Degrees Conferred December 19, 1989

Sherri Lynn Barker	Cornelius
Jerry Eugene Byrd	Mebane
†Anitra Marcelle Evans	Mebane
Daniel Patrick Halloran	Buffalo, NY
**Renee Lynn Harris	Troy
†Wesley Allen Harris	Lenoir
†Jeffrey Daran Hayes	Clemmons
Lori Lynn Kindsvatter	Cary
Bret Robin Kirby	Durham
John Frederick Millett	Charlotte
John Wesley Nobles	Raleigh

† Co-major * Cum Laude ** Magna Cum Laude *** Summa Cum Laude H Honors Program

Ronald Edwin Odom	Garner
Laura Leslie Paynter	Oxford
David Michael Quintilio	Asheville
Robert Edwin Reid	Winnsboro, SC
Charles Mitchum Terry	Knightdale

Degrees Conferred May 12, 1990

James Patrick Alcide	New City, NY
**Tania Rennalls Apsey	Knightdale
Angela Michele Atkinson	Burlington
Thomas John Beighley	Shelby
*Laura Catherine Betterton	Fayetteville
*Daniel Keith Bowman	Walnut Cove
Wendy Virnita Bradford	Kittrell
***Lisa Gayle Brooks	Pittsboro
Tammy James Butler	Clinton
*James Russell Capps, Jr.	Raleigh
**Hazel June Cockram	Patrick Springs, VA
Tracy Lynn Colby	Chesapeake, VA
Bryan Lynne Cope	Rocky Mount
*Wanda Joy Creech	Zebulon
Jean Byrnes Davis	Raleigh
Tiffany Heather Dern	Raleigh
Matthew Jean DesVergers	Whiteville
Amy Renee Edwards	Cary
**Gay Adelaide Edwards	Williamston
William Vincent Esoda	Haddon Heights, NJ
Jorge Ignacio Franchi	Annandale, VA
Samuel Horace Green	Fayetteville
**Millicent Lavonne Hawkins	Murfreesboro
Mark Andrew Inman	Mount Airy
Lee Ritchie Irvin	Fayetteville
**Chad Terence Jamison	Raleigh
Lesli Bryanne Johnson	Raleigh
Dorothy Mary Kirkman	Plainfield, NJ
Michael John Kurak	Swansboro
Jennifer Carole Lance	Asheville
**Stephen Robert Larson	Apex
Angela Marie Lucas	Roanoke Rapids
Richard Alan McCall	Lexington
Michaela Lynn McClure	Knightdale
Bart Matthew McGowan	Raleigh
Elizabeth Ashley McLamb	Hillsborough
Glenda Elizabeth Myers	Raleigh
Amy Eileen Nettesheim	Raleigh
**Ginger Losch Osteen	Hopkinsville, KY
Brad Courtland Parris	Rome, GA
Deborah Lynn Patafio	Cary
Beverly Lynn Patrick	Wake Forest
*Jill Suzanne Poindexter	Charlotte
Brian Lee Puckett	Nashville
**Jonathan Blake Riggsbee	Durham
Reetika Sachdev	Greensboro
Wendy Elizabeth Sanderson	Raleigh
*James Anthony Sessoms	Clinton
Christopher Scott Smith	High Point
***Thomasina Elizabeth Stikeleather	Kernersville
Jeffrone Thompson	Raleigh

†William Jerome Tingen	Oxford
*Annette Hubbard Turner	Valdese
Robert Kenneth Updegrave, Jr.	Raleigh
*Patricia Lynn Watson	Olney, MD
***Rose Casanave White	Apex
Jeffrey William Williams	Clayton
**Matthew Cole Williams	Clayton
*Anita Carol Woher	Raleigh
**Tracy Ann Womble	Goldsboro
Patria Ruth Wrenn	Louisburg

BACHELOR OF ARTS IN BUSINESS MANAGEMENT

Degrees Conferred June 27, 1989

†Dena George Ashoo	Bacshdad, Iraq
*Annette Couture Beach	Dayton, OH
April Renee Betts	Charlotte
Bowen Deitz Carpenter	Salisbury
William Bragg Carswell, Jr.	Raleigh
Rhonda Jean Cielo	Raleigh
Jacqueline Wilson Cosgrove	Potomac, MD
Karl Lynn Daeke	Norlina
Michael Currie Davenport	Sanford
†Sherri Lea Dedmon	Salisbury
†Thaddeus Paul Downing	Fayetteville
Kevin Alan Dunion	Wilmington, DE
Martin Lane Efird, Jr.	Matthews
Orland Edward Esval	Hendersonville
Paul Henry Foglia	Raleigh
Kenneth Paul Forte, Jr.	Huntsville, Alabama
Stephanie Loretta Fox	Sanford
†Sherri Denise Harris	Charlotte
Amy Marie Hopkins	Durham
Tonya Sha Kennedy	Charlotte
Stephan Andreas Lampert	Hickory
Christopher Raymond Mason	Statesville
†Barrett Wayne Mills	Raleigh
James Edwin Moten II	Raleigh
Chau Don Nguyen	Goldsboro
Karen Elaine O'Rear	Charlotte
Patrick Sean Plettner	Raleigh
Ernest Gordon Poole	Charlotte
Rebecca Marie Reucher	Charlotte
David Wayne Rivers	Raleigh
Keith Michael Sigworth	Raleigh
Mary Alice Stewart	Matthews
†Howard Julius Stott	Roanoke, VA
Clay Matthew Strickland	Salemberg
Richard James Tackabery	Southern Pines
H Jayne Regina Waida	Newport News, VA
Warren Timothy Webb	Burlington
*Kimberley Gwyn Whittington	Roaring River

Degrees Conferred August 9, 1989

Cecilia Maria Ancalmo	San Salvador, El Salvador
Paul Crenshaw Briggs	Raleigh
Rhonda Michelle Brock	Cary
Jonathan Davis Capps	Warrenton

†Co-major *Cum Laude **Magna Cum Laude ***Summa Cum Laude H Honors Program

Nicole Chellew	Smithfield
Mitchell Gray Cox	Walnut Cove
Angela Denise Evans	Oxford
Vivian Louise Fish	Willow Spring
Patrick Robert Gaines	Fayetteville
Lynn Marie Hayes	Cary
†Jeffrey Paul Huneycutt	Cary
Russell Joseph Johnson	Fayetteville
Paul Scott Jones II	Raleigh
†Ross Allen Jones	Raleigh
Karen Denise Kanto	Manassas, VA
Rodney Lee Kendrick	Burlington
†Yvette Renee King	Kinston
Thomas Jordan Lea	Greenville, SC
Tammy Dennis Liles	Norwood
Michael Johnson Lotz	Sarasota, FL
*Karen Smith Marceau	Chapel Hill
Charles Edward Morgan	Burlington
Margaret Elizabeth Myers	Raleigh
†Ted Wallace Owen, Jr.	Fayetteville
Laura Elean Patterson	Fayetteville
Steve Kiatipong Pongpairoj	Raleigh
Kimberly Sue Price	Raleigh
Reetika Sachdev	Greensboro
Eric Dale Spell	Clinton
Patricia Annette Stefanovic	Wake Forest
Angela Lynn Vinson	Lexington
Thad David White	Salisbury
*Everette Alan Whitley	Havelock
†*Jennifer Ann Willson	Raleigh

Degrees Conferred December 19, 1989

**James Sidney Achurch	Cary
†Leon David Adams	Ramseur
†Donald McGaughay Alexander	Savannah, Ga.
†Cynthia Edith Astalos	Fayetteville
†Benjamin Lee Bailey	Granite Falls
Keri Uram Baker	Raleigh
†Matthew Lee Baldwin	Siler City
Frank Robert Banesse	High Point
Carolista Ann-Cabell Baum	Nags Head
Linda M'Shel Beam	Cherryville
Phillip Berlin Bollinger	Granite Falls
Misty Jo Britton	Hamlet
Jeffrey Scott Brookshire	Flat Rock
†Angela Suzanne Broome	Smithfield
Mary Patricia Burton	Norlina
Serena Vittoria Cantoni	Bethesda, MD
Lamonica Alesia Carr	Willard
**Christopher Alan Caskey	Cary
Elsbeth Jean Chapman	Rougemont
Paul Haslett Collie	Durham
Bradrick Coy Crawford	Greensboro
Charles Scott Creighton	Edenton
Wendy Renee Cushman	Jacksonville
Raeform Van Daughtry	Newton Grove
Shawn Ashley Davenport	Statesville
†Hal Daniel Davis	Henderson
John Lawrence Davis, Jr.	Raleigh

† Co-major

* Cum Laude

** Magna Cum Laude

*** Summa Cum Laude

H Honors Program

*Matthew Courtney Davis	Louisburg
James Christopher Deal	Hildebran
Deborah Ann Dickerson	Raleigh
Christine Anne Donaghy	Raleigh
Robert Crawford Edwards	Kernersville
**Christal Faith Elliott	Oxford
†Anitra Marcelle Evans	Mebane
***Elizabeth Price Feild	Belmont
Brian Franklin Gay	Greensboro
Michael Curtis George	Raleigh
William Henry George, Jr.	Raleigh
Scott Edward Gingery	Raleigh
Bryan Scott Goldman	Spartanburg, SC
Brian Francis Goodrich	Cherry Hill, NJ
Kathryn Lane Graham	Cary
Jon Eric Grant	Wilson
Noreen Mary Gray	Rhinebeck, NY
Ty Graham Hardison	Greensboro
†Wesley Allen Harris	Lenoir
Donald Alexander Harte, Jr.	Mooresville
Heather Marie Hayes	Winston-Salem
†Jeffrey Daran Hayes	Clemmons
†Matthew Daniel Hedrick	Winston-Salem
Janet Moore Hicks	Wilmington
Bonnie Sue Hines	Wilson
Jeffrey Arthur Hojnacki	Shelby
†Yvonne Nannette Howey	Charlotte
Travis Teavie Hubbard	Raleigh
†Russell Ray Ingram	Greensboro
Kimberly June Ivey	Oxford
†*Stefanie Anne Jernigan	Fayetteville
†Katherine Preston Kasprzak	Alexandria, VA
Demetra Constance Katsoudas	Sanford
Donna Lynn Kelley	Raleigh
Clara Y. Kim	Allentown, PA
†Edward James King III	Carolina Beach
Gerald Michael Kinlaw	Greensboro
William James Klenoshek, Jr.	Lyndhurst, OH
Robert Ralph Krueger	Raleigh
Charles Patrick Long	Apex
Jeffrey Stephen Loveless	Wilmington
Jeane McCombs Mathis	Raleigh
†James Brian McDaniel	Concord
Deidre Lee Mehalic	Shallotte
†Joseph Bradford Mickle	Salisbury
**Gary Raymond Miklos	Raleigh
James Kenneth Mills, Jr.	Asheville
Amy Elizabeth Murphey	Clayton
Douglas Brian Nixon	Charlotte
Thad Edward Noe	Lebanon, OH
*Dawn Marie Oslund	Cary
Marshall Hamilton Page	Jacksonville
Roy Craig Parrott	Oxford
Melinda Ann Pearce	Zebulon
Melinda Gay Penuel	Jacksonville
William Whiteley Procter	Raleigh
Michael Steve Rabb, Jr.	Shelby
Dale Lynn Reiber	Springfield, VA
Robert Roosevelt Rice II	Mount Olive

James Matthew Richardson	Orange, NJ
William Arthur Robertson	Raleigh
H†Ronald Wayne Rogers	Mebane
†Richard Kurt Rouse	Charlotte
†David Derrell Sapp	Knightdale
†Malcolm Boyd Sluder	Asheville
Patricia Jo Small	High Point
Harry Lamont Southerland	Raeford
Patrick Lee Stanley	Tabor City
†Kurt Anthony Stengel	Allentown, PA
Michael Craig Stevens	Raleigh
†Scott Edward Strickland	Greensboro
Nathalia Suissa	Silver Spring, MD
Elizabeth Delphine Sullivan	Charlotte
†William Walker Swink, Jr.	Concord
†Steven Blane Talbert	Columbus, OH
Russell Eugene Teague IV	Raleigh
Robert Jackson Todd, Jr.	Wilmington
*Mark Graham Vickers	Raleigh
Nicole Elisabeth Wagner	Raleigh
Richard Lindsay Walker III	Charlotte
Todd Randall Walker	High Point
†Darien Russell Waters	Washington
***William Parker Watkins, Jr.	Morrisville
**Rose Casanave White	Apex
David Michael Wood	Durham
Kimberly Sharon Wooldridge	Raleigh
Todd Thomas Yates	Durham

Degrees Conferred May 12, 1990

Timothy Arthur Adams	Raleigh
†Eric Michael Alber	Ocean City, NJ
Jeffrey Richard Alexander	Pittsford, NY
Julie Michelle Allen	Burlington
Stephanie Denise Alston	Brooklyn, NY
Carol Lynnette Altman	Dunn
Michael Duane Alway	Pembroke
Regina Reine Anderson	Baltimore, MD
Lisa Lynn Angel	Raleigh
James Murray Askew III	Maxton
Jerome Herbert Askew, Jr.	Fayetteville
†Donna Marie Ballard	Conover
Kyle Allen Barger	Raleigh
Jeffery Todd Barnhardt	Mocksville
†Melinda Barrier	Raleigh
Ronald Lander Baucom	Charlotte
Katherine Anne Bauernfeind	Louisville, KY
†Amy Gibbs Beal	Charlotte
Walter Lewis Scott Bean III	Jamestown
Benjamin Forrest Beasley	Gastonia
Cartaveta Rochell Belcher	Plymouth
†André Bigford	Fayetteville
†Courtenay Lee Blair	Hendersonville
Kelly Jeneé Blair	Charlotte
Mary-Anne Boda	Raleigh
Matthew DeWane Brenner	Centerville, OH
†Andrew Lyon Brewer	Misenheimer
Joseph Joy Briggs	Goldsboro
David Thomas Bryant	New Bern

†Co-major

*Cum Laude

**Magna Cum Laude

***Summa Cum Laude

H Honors Program

David Russell Buchanan	Somers, NY
†Denise Irene Bullock	Raleigh
†Gina Bailey Bunch	Raleigh
Susan Marie Bur	Cary
Carlos Maurice Butler	Fayetteville
John Thomas Canoutas	Wilmington
Yoskana Capino	Fayetteville
†**Dara Quayle Caricofe	Apex
David Burr Carr	Charlotte
Mary Ann Carraher	Sanford
Mary Harley Castles	Charlotte
Steven Paul Cesari	Ashland, PA
Mason Travers Chapman	Richmond, VA
Roger Orville Church, Jr.	Charlotte
Marshall Heath Clayton	Cary
Latanya Demetria Clemons	Chapel Hill
Edward Anthony Coats	Raleigh
*Charles Godwin Cobb	West Columbia, SC
†Tammi Michelle Coleman	Charlotte
John Howard Collar III	Raleigh
†John Martin Collins	Raleigh
William Brett Collins	Thomasville
Brian Matthew Cooney	Raleigh
Kimberly Paige Curlee	Charlotte
Amy Suzanne Davis	Lexington
Daniel Lee Davis	High Point
James Coolidge Davis	Hendersonville
Brian David Depenbrock	Charlotte
†Jacqueline Gale DiGregorio	Raleigh
Lisa Marie Dombrowski	Raleigh
Kathryn Elizabeth Dominick	Raleigh
Jerry Campbell Douglass	Fayetteville
Derek Fred Duin	Sewickley, PA
*Heather Folden Dunn	Raleigh
Sara Nicholasas Dunnam	Salisbury
Sedrick Ramone Dunson	Goldsboro
Jessica Eason	Tarboro
**William Wayne Edwards	Chico, CA
†Robert Joe Ellison, Jr.	Charlotte
†Kelly Ann Erhardt	Colts Neck, NJ
*Stacy Elizabeth Ernest	Pittsboro, FL
Daniel Eugene Evans	Raleigh
Susan Eileen Evans	Wendell
†Jeffrey Stuart Flake	Greenville
Regina Ellen Flythe	Conway
†Shannon Leigh Fulk	King
Paul Joseph Gaglione	Charlotte
†Jennifer Jean Gaither	Statesville
Michele Monique Gambaro	Gloversville, NY
**Lori Anne Gard	Hertford
Beth Anne Gilpin	Newport
†Henry Russell Grant	Weldon
†Gary Thomas Greene	Raleigh
†Julie Anne Grisdale	Charlotte
Tamara Jo Grissom	Cary
Donna Michelle Gunter	New Hill
Kristin Anne Hale	Dallas, TX
Charles Jeffrey Hancock	Greensboro
†Carolyn Jean Handy	Midlothian, VA

Susan Lynn Hennis	Winston-Salem
*Gregory Carl Henry	Raleigh
Vickie Diane Hildebran	Hickory
Gerhard Holger Hillmann	Cincinnati, OH
†*David Lee Houser	Cherryville
Ines Marie Huber	Canton
William Hughes	Raleigh
Earl Maxwell Inge, Jr.	Greensboro
Kendra Renee Johnson	Fayetteville
Kenneth Preston Jones	New Bern
Stewart Christopher Jones	North Wilkesboro
William Kent Jordan, Jr.	Athens, GA
Patrick Keith Kalebma	Raleigh
†Stacy Lea Kishpaugh	Raleigh
Mary Healy Lecoivre	Westboro, MA
Timothy Franklin Lindsay	Clinton
Angela Rae Long	Raleigh
Jason Timothy Long	Wilson
Mary Elizabeth Manners	Springfield, VA
Brennan Parks Marilla	Richmond, VA
†Terence Lorenzo Matthews	Fort Washington, MD
Wade Glenn Mauser	Hickory
Susanne Michelle Mayo	Durham
John Amos Mecimore	Greensboro
Sheridan Adair Medlin	Charlotte
†Roberta Jean Merrifield	Linwood, NJ
Alicia Ann Messina	New Providence, NJ
Courtney Scot Michelle	Asheboro
†Craig Allen Miller	Kansas City, MO
Robert Bruce Miller	Burlington
†Mark Francis Molinaro	Durham
†Shane Michael Montgomery	Newark, OH
Jane Ashley Morris	New Bern
†Karen Ann Mullaney	Rockville, MD
Susan Mary Mullaney	Kensington, MD
†*Michelle Elizabeth Mumm	Boca Raton, FL
Dana Lynette Navey	Lincolnton
Charles Matthews Neese	Greensboro
Joseph Ray Nichols, Jr.	Ahoskie
†Brian Lamar Nixon	Denver
†Larry Gene Norris, Jr.	Garner
Joseph Warren Nowell	Elizabeth City
*Tracy Dianne O'Berry	Ahoskie
Lesley Carmen O'Brien	Raleigh
†Michael Allan Olson	Reston, VA
Angela Renee Page	Ruffin
Kevin Douglas Pegram	Raleigh
**Carol Wightman Petrie	Los Angeles, CA
Charles Leon Phillips II	Morrisville
Jeffrey Scott Pickett	Durham
Kelly Elizabeth Pierce	Raleigh
Timothy Scott Pope	Charlotte
Nila Leigh Price	Garner
†John Craig Richards	Richmond, VA
Falisa Wynette Richardson	Castalia
Tammy Marie Rigney	McLeansville
Stacey Lynn Roberts	Raleigh
†Gerald Rogers, Jr.	Shelby
Travis Cornell Rouse	Washington

†Co-major

*Cum Laude

**Magna Cum Laude

***Summa Cum Laude

H Honors Program

†Michael Bruce Rundle	Raleigh
Andrew Keith Sandman	Raleigh
Michael Daniel Schiewe	Raleigh
Gregory Criston Schultz	Charlotte
†Stephen Smith Scott	Winston-Salem
Robert Blakley Settle	Raleigh
†Parag Natver Shah	Raleigh
Mary Elizabeth Sharp	Aiken, SC
SueAnn Sheehan	Charlotte
Christopher McBrayer Shoffner	Raleigh
†Brad Lee Siebert	Raleigh
Leslie Diane Silva	Wayne, PA
Bryan Todd Simpson	Raleigh
Jeffrey Scott Smith	Raleigh
†Michael Darin Smith	Raleigh
Gregory Ray Stallings	Raleigh
†Leanne Stepanovich	Altoona, PA
David Byron Stone	Salisbury
Walter Carl Stone	Durham
Cameron Wiley Stout	Fayetteville
Stephanie Rose Stubbs	Whiteville
*Marion Manton Suchy	Raleigh
John Allan Suther	Concord
†Sandra JoAnne Taylor	New Bern
Michael Shan Teel	Lumberton
Sandra Joette Thomas	Pittsboro
†Rebecca Louise Thompson	Greenville
Carolyn Amelia Thornell	Raleigh
Rosemarie Estrellita Tikvart	Raleigh
†William Jerome Tingen	Oxford
†Nicole Toole	Henderson
Timothy Charles Troutman	Lenoir
Jennifer Kristen Utter	Greensboro
Kimberly Hope Varnell	Pinetops
Joseph Patrick White	Oxford
†Marjorie Leigh Whitfield	Hillsborough
Christy Lee Whitley	Sanford
†Franklin Edward Wickizer	Swansboro
Donald Scott Williams	Durham
Gregory Monroe Williams	Sanford
Jason Reed Williams	Cary
Diane Michele Willingham	New Bern
Brian Alan Wilson	Charleston, WV
Lisa Lorraine Wilson	Roanoke Rapids
Steven Wayne Wood	Raleigh
*Tammie Lynette Wray	Stoneville

BACHELOR OF ARTS IN ECONOMICS

Degrees Conferred June 27, 1989

†Dena George Ashoo	Bacshdad, Iraq
†Sherri Lea Dedmon	Salisbury
†Thaddeus Paul Downing	Fayetteville
†Sherri Denise Harris	Charlotte
Joel Farris Kincaid	Lake Lure
H Bruce Robert Millar	Raleigh
†Barrett Wayne Mills	Raleigh
Jodi Lynn Vogel	Jacksonville

† Co-major

* Cum Laude

** Magna Cum Laude

*** Summa Cum Laude

H Honors Program

Degrees Conferred August 9, 1989

†Jeffrey Paul Huneycutt	Cary
Ross Allen Jones	Raleigh
†Yvette Renee King	Kinston
Andrew Matejka	New City, NY
†Ted Wallace Owen, Jr.	Fayetteville
Jean Marie Parrott	Raleigh
Eric Jordan Speece	Carrboro
†*Jennifer Ann Willson	Raleigh

Degrees Conferred December 19, 1989

†Leon David Adams	Ramseur
†Donald McGaughay Alexander	Savannah, GA
†Cynthia Edith Astalos	Fayetteville
†Benjamin Lee Bailey	Granite Falls
†Matthew Lee Baldwin	Siler City
Kimberly Dawn Banks	Raleigh
Steve Tyler Bland	Raleigh
†Angela Suzanne Broome	Smithfield
James Patrick Costello	Washington, CT
†Hal Daniel Davis	Henderson
James Lawrence Devereux II	Charlotte
David Lawrence Hatcher	Raleigh
†Matthew Daniel Hedrick	Winston-Salem
†Yvonne Nannette Howey	Charlotte
†Russell Ray Ingram	Greensboro
†*Stefanie Anne Jernigan	Fayetteville
†Katherine Preston Kasprzak	Alexandria, VA
†Edward James King III	Carolina Beach
†***James Matthew Matson	Eden
†James Brian McDaniel	Concord
Michael Lawton McQueen	Raleigh
†Joseph Bradford Mickle	Salisbury
†Ronald Wayne Rogers	Mebane
†Richard Kurt Rouse	Charlotte
†David Derrell Sapp	Knightsdale
Kenya Shiver	Brooklyn, NY
†Malcolm Boyd Sluder	Asheville
†*Arthur R. Spruill III	Plymouth
†Kurt Anthony Stengel	Allentown, PA
†Scott Edward Strickland	Greensboro
Thomas Eugene Sutton	Salisbury
†William Walker Swink, Jr.	Concord
†Steven Blane Talbert	Columbus, OH
†Darien Russell Waters	Washington

Degrees Conferred May 12, 1990

†Eric Michael Alber	Ocean City, NJ
†Donna Marie Ballard	Conover
†Amy Gibbs Beal	Charlotte
Linda M'Shel Beam	Cherryville
†Andre Bigford	Fayetteville
†Courtenay Lee Blair	Hendersonville
†Andrew Lyon Brewer	Misenheimer
†Denise Irene Bullock	Raleigh
†Gina Bailey Bunch	Raleigh
†**Dara Quayle Caricofe	Apex
†Tammi Michelle Coleman	Charlotte

† Co-major * Cum Laude ** Magna Cum Laude *** Summa Cum Laude H Honors Program

†John Martin Collins	Raleigh
Lisa Michelle Derrickson	Raleigh
†Jacqueline Gale DiGregorio	Raleigh
†Robert Joe Ellison, Jr.	Charlotte
†Kelly Ann Erhardt	Colts Neck, NJ
†Jeffrey Stuart Flake	Greenville
†Shannon Leigh Fulk	King
Patrick Robert Gaines	Fayetteville
†Jennifer Jean Gaither	Statesville
†Henry Russell Grant	Weldon
†Gary Thomas Greene	Raleigh
†Julie Anne Grisdale	Charlotte
†Carolyn Jean Handy	Midlothian, VA
†*David Lee Houser	Cherryville
Robert Scott Jasany	Sanford
†Stacy Lea Kishpaugh	Raleigh
Robert Anthony Ladd	Charlotte
†Terence Lorenzo Matthews	Fort Washington, MD
Gregory Allen Millar	Raleigh
†Craig Allen Miller	Kansas City, MO
†Mark Francis Molinaro	Durham
†Shane Michael Montgomery	Newark, OH
†Karen Ann Mullaney	Rockville, MD
†*Michelle Elizabeth Mumm	Boca Raton, FL
†Brian Lamar Nixon	Denver
†Larry Gene Norris, Jr.	Garner
†Michael Allan Olson	Reston, VA
Steven Curtis Pellingier	Cary
Matthew Peter Pitman	Canton
†John Craig Richards	Richmond, VA
†Gerald Rogers, Jr.	Shelby
David Arnold Rose	Washington
†Michael Bruce Rundle	Raleigh
Louis Henry Sawyer, Jr.	Wilmington
†Stephen Smith Scott	Winston-Salem
†Parag Natver Shah	Raleigh
†Brad Lee Siebert	Raleigh
†Michael Darin Smith	Raleigh
Harry Lamont Southerland	Raeford
†Sandra JoAnne Taylor	New Bern
†Nicole Toole	Henderson
†Marjorie Leigh Whitfield	Hillsborough
†Franklin Edward Wickizer	Swansboro
Norman Cole Williams	Durham

BACHELOR OF SCIENCE IN ECONOMICS

Degrees Conferred June 27, 1989

Karen Michele Beamon	Candler
John David Capps	Raleigh
H Andrew Kevin Frye	Carthage

Degrees Conferred August 9, 1989

Jo-Nette Anita Boyd	Raleigh
Walid Urabi Mustafa	Raleigh

Degrees Conferred December 19, 1989

Robert Pell Bovender III	Charlotte
Mark Stevens Conord	New Bern
Jeannette Sandra Ellison	Raleigh
†***Christopher Walker Johnson	Fuquay-Varina
Preston Michael Miller	Raleigh
Timothy Lynn Pratt	Wilmington
Larry Cleon Reece	Greensboro
Bryan Everett Roberson	Raleigh
Peter Anthony Rowe	Conover
Wendy Earle Ryals	Raleigh
Mark James Senter	Garner
David Monroe Shackelford	Asheboro
Thomas Neil Sullivan	Raleigh
Roger Steele Turner	Mount Olive

Degrees Conferred May 12, 1990

†Melinda Barrier	Raleigh
*Paula Boulware Coe	Lincolnton
†**Christopher Frank Dumas	Wilmington
William Greswold Gwynette	Shelby
John David Horton	Burnsville
John Michael Kovach	Aquasco, MD
Roger Lanier McDaniel, Jr.	Raleigh
Robert Tyra Morris	Marion
Scott Morgan Parrish	Hickory
Stephen Bradshaw Picklesimer	High Point
Julie Anne Resager	Massapequa, NY
Marvin Jay Scotton	Coleridge
Brendt Caldwell Swink	Atlanta, GA
†Robert Allen Venezia	Cary
Michael Zapata III	Cary

BACHELOR OF ARTS IN ENGLISH

Degrees Conferred June 27, 1989

Tracey Simpson Kyles	Sanford
H***Kathleen Roberta Somers	Long Beach
H**Barry Lyman Thatcher	Rexburg, ID
Janet Marie Turner	Lumberton

Degrees Conferred August 9, 1989

†*Donna Annette Burge	Raleigh
Carmen Newkirk Davis	Magnolia
Darcy Ellen Dye	Raleigh
Evelyn Safadi Grizzard	Raleigh
Marlo Jeanette Howell	Hertford
***Teresa Marie Hudson	Raleigh
*Lori Lynne McKinney	Atchison, KS

Degrees Conferred December 19, 1989

Peggy LouAnn Bowen	Kinston
Lawrence McGilbra Cutchin, Jr.	Weldon
H***Judith Ellen Darling	Garner
Catherine Ann Dugger	Raleigh
Angela Hall Hanson	Lawsonville
*Andrea Camilla Hardy	Durham

† Co-major * Cum Laude ** Magna Cum Laude *** Summa Cum Laude H Honors Program

George Edward Romaine Hervey III	Raleigh
*William Elliot Inman	Raleigh
Joanne Mary Kempen	Greensboro
Neil Chapin Koomen	Raleigh
Joseph Allen McFaden, Jr.	Madison Heights, VA
Ian Andrew McKenzie	Asheville
Laura Kathryn Peacock	Cary
Thomas Gregg Phillips	Cary
Benjamin Brent Poteat	Wrightsville Beach
Kelly Leigh Smith	Fuquay-Varina
Zina Suzanne Stewart	Wilson, CT
Lisa Jones Wheeler	Garner
Jodi Ann Zinnanti	Raleigh

Degrees Conferred May 12, 1990

William Neil Armstrong	Charlotte
Jennifer Ingraham Atherton	Cortland, NY
James Darren Balentine	Charlotte
Tina Egsegian Berger	Fuquay-Varina
Christina Biilouris	Fayetteville
H*Haley Sean Boone	Burlington
H*Amy Lautares Bracken	Sanford
***Susan Elizabeth Brooks	Whiteville
Dawn Elizabeth Cobb	Raleigh
Renee Elizabeth Coley	Concord
H*Lisa Ellen Coston	Greensboro
Dawn Love DeBruhl	Winston-Salem
Larry Edward Dugger	Cary
**Emily Kay Durham	Burlington
Samson Alexander Eymer	Raleigh
Robin Snead Ferguson	Dallas, TX
H*Cherry Lurae Flake	Farmville
Joseph Mark Freeman III	New Bern
Samuel Douglas Gatlin	Belmont
Andrew Wayne Gunderson	Hendersonville
Margaret Mary Harrington	Raleigh
James Floyd Hedgpeth, Jr.	Laurinburg
Amy Elizabeth Hilt	Newport News, VA
Carla Ann Hogue	Charlotte
Shanelle Wanet Hunter	Raleigh
**Donald Craig Johnson	Garner
Dwuan Dorsa June	Gastonia
Ken Chin Kam	Kuala Lumpur, Malaysia
Susan Kotzan	Raleigh
Lanita Yvette Lowery	Wadesboro
Shenita Paulette Mangum	Robersonville
Lisa Caroline Mooring	Concord
H*Suzanne Patricia Perez	Fayetteville
Michael Andrew Petrizzo	Massapequa, NY
**Deborah Ragland Ragland	Clayton
**James Green Rea, Jr.	Charlotte
David Edward Shapiro	Raleigh
Natasha Eugenia Vale	Gastonia
Becky Anne White	Edenton
Dana Marie White	Burke, VA
David Sloan White	Burke, VA
John Latham Whitfield	Wendell
Emma Susan Windsor	Charlotte

BACHELOR OF ARTS IN FRENCH LANGUAGE AND LITERATURE

Degree Conferred June 27, 1989

*Betty Jane Glasgow Raleigh

Degrees Conferred August 9, 1989

Sherri Alicia Ellerbe Capital Heights, MD
†Ann Elizabeth Horvath Silver Spring, MD

BACHELOR OF ARTS IN HISTORY

Degrees Conferred June 27, 1989

Lisa Ann Clark Siler City
Brian Melvin Huffstetler Shelby
Michael Eugene McDaniel Elizabeth City
Daryle Scott Zechini Lynchburg, VA

Degrees Conferred August 9, 1989

Lee Gerard Beford Matthews
Colette Michelle Love Chapel Hill
Nancy Jo Martin San Diego, CA
John Thomas Miller Goldsboro
David Lee Perry Morehead City
John Charles Ray, Jr. Raleigh
Paul Robert Shannon Rocky Mount
William Brock Slade Scotland Neck

Degrees Conferred December 19, 1989

*Laura Ann Alphin Mount Olive
Stephen Patrick Croushore Alexandria, VA
Judy Ann Harris Charlotte
*Lynda Gaye Moser Vienna, VA
Con Andrew Phillips Raleigh
**Cynthia Siira Robbins St. Cloud, MN
Paul Alan Starling Dunn
John David Szymeczek Washington

Degrees Conferred May 12, 1990

***Kim Ray Annas Wake Forest
Peter John Blutreich Wingate
Tiffany Nicole Boggs Lincolnton
Kenneth Goodwin Bunn Oxford
Sharon Ann Cannady Clinton
James Reece Caviness Chadbourne
***Lewis Norman Cornwall Goldsboro
David Caldwell Dixon Charlotte
Michael Edward Dixon Charlotte
*Van Ray Freeman, Jr. Apex
Sonya Deneé Kiser Winston-Salem
Kevrick Timothy McKain Eden
Jeffrey Allen Merritt Grifton
Michael Todd Nelson Kernersville
Philip Overton Ross Raleigh
James Bruce Runyon Hopkinsville, KY
***Steven John Russ East Detroit, MI
**Anne Elizabeth Slifer Atlanta, GA
**Crystal Lynn Spivey Sanford

† Co-major

* Cum Laude

** Magna Cum Laude

*** Summa Cum Laude

H Honors Program

*Edgar Linwood Thompson	Cary
James Shannon Toole	Syracuse, NY
*Marsha Jo Traylor	Washington, DC
Robert Richard Weil	Raleigh

BACHELOR OF SCIENCE IN HISTORY

Degrees Conferred December 19, 1989

Michael Stuart Prather	Raleigh
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Degree To Be Conferred May 12, 1990

Andrew Michael Smith II	Salisbury
†Donald Hugh Whitley	Goldsboro

BACHELOR OF ARTS IN MULTI-DISCIPLINARY STUDIES

Degrees Conferred June 27, 1989

Larry Robert Weger	Chicago, IL
Charla Faye Williams	Mebane

Degrees Conferred December 19, 1989

Benjamin Briggs II	High Point
Denise Marie Carlisle	Durham
Jean Marie Cartabiano	Richmond, VA
Susan Rosemary Efford	Wilmington
†***Dane Kinard Fisher	Salisbury
**Christopher Douglas Hoomani	Raleigh
†***Christopher Walker Johnson	Fuquay-Varina
†*Tiffany Paige Martz	Durham
Brock Allen Miller	Washington, PA
Hollie Renee Nicolaisen	Durham
†Edward Evans Smallwood	Durham

Degrees Conferred May 12, 1990

†*Robert Meredith Alexander	Boone
Annie Elizabeth Bartle	Raleigh
Margaret Ann Condon	Cincinnati, OH
Katherine Aline Gunther	Raleigh
Sammie Lyn Justice	Sneads Ferry
Elizabeth Louise Lancaster	Alexandria, VA
Katherine Helen Luetzelschwab	Littleton, CO
Craig Forrest Mathews	Denver
*Nathan Leroy McHenry	Durham
*Steven Gerard Muncy	Escanaba, MI
Kimberly Dawn Rosser	Sanford
Edward Lee Samuels	Wilmington
Cynthia Jewell Sawyer	Lynchburg, VA
*Dinah Austin Vannoy	Taylorsville

BACHELOR OF ARTS IN PHILOSOPHY

Degree Conferred June 27, 1989

***John Mason Bishop III	Raleigh
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Degrees Conferred December 19, 1989

Michael Joseph Ayers	Rocky Mount
***Amy Bailey Gray	Penland

†Co-major	*Cum Laude	**Magna Cum Laude	***Summa Cum Laude	H Honors Program
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Kevin Fulton McDonal	Raleigh
Golden Rayfield Smith	Shelby
Sally Catherine Trotter	Hickory

Degrees Conferred May 12, 1990

†David Herman Braxton	Durham
*Kevin Robert Downey	Raleigh
Robert Vaughn Funkh, Jr.	Fayetteville
Robert Edwin Via	Charlotte

BACHELOR OF SCIENCE IN PHILOSOPHY

Degree Conferred June 27, 1989

Jeffrey Paul Lundrigan	High Point
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Degrees Conferred May 12, 1990

†**Henry Herbert Jacumin, Jr.	Rutherford College
*Kimberly Lynn Stitzinger	Raleigh

BACHELOR OF ARTS IN POLITICAL SCIENCE

Degrees Conferred June 27, 1989

Charles Wesley Albertson III	Richmond, VA
Terrence Eugene Evans	Havelock
Gary Smith Morgan	New Bern
Geoffrey Maurice Pearson	Lenoir
Helen Lewis Rigsbee	Durham
Elizabeth MacDonald Spurrier	Gastonia
Scott Fitzgerald Stevens	Raleigh
†Howard Julius Stott	Raleigh
Glenn Thomas Williamson	Aurora

Degrees Conferred August 9, 1989

Alex Robert Beguiristain	Coral Gables, FL
Christopher Daniel Blankenship	Cary
*Joseph Alton Bledsoe III	Fayetteville
†*Donna Annette Burge	Raleigh
Michael Richard Crovi	Charlotte
Dan Edward Dowse	Delavan, WI
†Ann Elizabeth Horvath	Silver Spring, MD
Christy Tant Oakley	Cary
**David Brian Slaughter	New Bern
Carolyn Patricia Veale	Lewiston
Frederick Scott White	Jacksonville
Bruce Junior Whitehead	Tarboro

Degrees Conferred December 19, 1989

Eric Michael Beam	Lincolnton
H**Robert Glenn Blanton	Shelby
Kevin Jarrett Bullard	Tabor City
Jason Anthony Burcham	Greensboro
**Marianne Elisabeth Coats	Raleigh
Mark William Coley	Raleigh
Randy Eugene Furr	Concord
Kim Noel Giannattasio	Raleigh
John Felix Green II	Franklinton
Charles Brinkley Hamm	Tarboro

† Co-major * Cum Laude ** Magna Cum Laude *** Summa Cum Laude H Honors Program

Bradley Walker Hoffman	Gastonia
John David Lennon	Washington, DC
Nola LaCount Maingi	Raleigh
Joel Patrick McCullough	Raleigh
*Paul Gregory McKenzie	Greensboro
Natalie Marie Phillips	Raleigh
Anne Kathryn Poole	Salemberg
Michelle Deneen Pope	Charlotte
Ronald William Pope, Jr.	Concord
**Lindsey Elizabeth Roebuck	Burke, VA
Mark Douglas Sheets	Mocksville
*William Eric Taylor	Greensboro
William Jordan Taylor	Wilson
Luther Thomas, Jr.	Laurinburg

Degrees Conferred May 12, 1990

H*Elizabeth Mazyck Baggett	New Bern
*Stephen Garrel Banta	Viroqua, WI
Angela Carol Beavers	Siler City
Joanna Biliouris	Fayetteville
Jonathan Bradley Blake	Sanford
Stephon John Bowens	Raleigh
Wendy Kaye Brantley	Bunn
†David Herman Braxton	Durham
Lee Elkins Britt	Connelly Springs
Timothy James Cameron	Carthage
Eric Lynn Copeland	Belvidere
Yvette Elsie Cropper	Stamford, CT
Matthew Wayne Dean	Hickory
H*Leo Patrick Dacey	Wall Township, NJ
Teresa DeLoatch	Tarboro
**Laura Ann Edgerton	Alexandria, VA
Michael Henry Edmonds	Garner
**Douglas Bruce Elliott	Greensboro
William Francis Finn, Jr.	Chapel Hill
*Angela Carol Gentry	Charlotte
*Blair Thomas Glass	Lynchburg, VA
Anthony Lynn Godwin	Raleigh
Daniel Wayne Hague	Asheville
Warren Adomis Harris	Durham
Kenneth Wayne Hawley	Erwin
†Kara Eileen Heizer	Chapel Hill
Otis Craig Kempson	Asheville
Timothy John Krings	Fayetteville
Margaret Elizabeth Lancaster	Rockville, MD
*Scott Evan Leo	Raleigh
Stacy Lynn Long	Herndon, VA
David Goodwin Loyack	Lawrenceville, NJ
†Billy Dal Maddalon	Charlotte
Jeremy Scott Maddox	Greensboro
Ronald Christopher Mayer	Hampton Bays, NY
†Roberta Jean Merrifield	Linwood, NJ
*Daniel Raymond Palese	Danbury, CT
Michael Scott Sailer	Amelia, VA
Karen Elizabeth Ramsing Schroeder	Fort Leonardwood, MO
Leah Michelle Smith	Charlotte
William Drew Stanley	Nashville
Scott Alan Swindell	Cary

† Co-major * Cum Laude ** Magna Cum Laude *** Summa Cum Laude H Honors Program

Stephen Ray Taylor	Raleigh
*Suzanne Marie Thomas	Raleigh
H*Stacye Joele Tolin	Summerfield
James Brian Trantham	Kannapolis
*Michael Sean Turner	Greensboro
Elizabeth Eva Wall	Manion
Tom Smith Whiting	Raleigh
Kirk Ashley Wilder	Richmond, VA
Lee Andrew Willis III	New Bern
Mark Daniel Woodworth	Raleigh

BACHELOR OF SCIENCE IN POLITICAL SCIENCE

Degrees Conferred December 19, 1989

Perry Cassimus Craver	Freehold, NJ
**Glenn Edward Hamilton	Raleigh
James Howard Hickland	Laurel Springs
†***Christopher Walker Johnson	Fuquay-Varina

Degrees Conferred May 12, 1990

†*Joseph Asiano Nguyen	Greensboro
David Jonathan Sullivan	Pine Level
*John Richard Witcher III	Lumberton
†Donald Hugh Whitley	Goldsboro

BACHELOR OF ARTS IN SOCIOLOGY

Degrees Conferred June 27, 1989

Bruce Thomas Gentry	Lumberton
Jane Woodbury Johnson	Greensboro
Nydia Felicia Jones	Dillwyn, VA
Robin Michelle Jones	Winston-Salem
Lynn Maria Krajack	Charlotte
Crystal Dawn Waters	New Bern
Christopher Bryan Yates	Charlotte
†Miren Karoline Zubizarreta	Caracas, Venezuela

Degrees Conferred August 9, 1989

Adene Yolanda Black	Cary
Jacqueline Rose Edards	Princeton
Alcie Susan Gordon	Wilson
Jill Rene Kohake	Cary
Dawn-Elise Kehaulani Miller	Roanoke, VA
Mark Jefferson Strickland	Roseboro

Degrees Conferred December 19, 1989

Cassandra Lynn Bell	Raleigh
*Laura Ann Bradford	Sanford
Lynn Michelle Brandon	Wake Forest
Kimberly Annette Bulluck	Rocky Mount
Gwen Denise Daves	Raleigh
Jenita Lynn Flowers	Sherrills Ford
Diatra Allyn Fullwood	Morganton
Virginia Francine Harrell	Goldsboro
Danae Elizabeth Lamm	Rocky Mount
Michele Ann Mannino	Cary
***Ellen Christine Miller	Landis

† Co-major * Cum Laude ** Magna Cum Laude *** Summa Cum Laude H Honors Program

Sharon Marie Rhew	Morrisville
Nicole Kirsten Stell	Cary

Degrees Conferred May 12, 1990

Melanie Terayne Agnew	Winston-Salem
James Thomas Anderson	Greensboro
*Mark John Beech	Cary
Leigh Ashley Blankinship	Raleigh
*Donna Leigh Boyette	Wilson
Amanda Carol Driesbach	Raleigh
Tracie Noel Duncan	High Point
Jennifer Lynn Evans	Raleigh
Ronald Scott Gantt	Mocksville
Carolyn Kay Grealey	Cary
**Carey Nelson Gregory	Advance
Rodney L Hamrick	Raleigh
David Glen Holton	Spring Lake
Suzanne Patrice Lawrence	Durham
Denise Renee Lozares	Rockingham
**Nancy Neff	Raleigh
Joseph Daniel Nye II	Raleigh
Christine Marie O'Sullivan	Cinnaminson, NJ
Frank Louis Powers	Lillington
**Alma Katherine Renfrow	Wilson
Stephen Ramseur Schenck	Greensboro
Kimberly Annette Smith	Raleigh
Gregory Eugene Spence	Raleigh
Amanda Elaine Talley	Silver Spring, MD
Regina Fay Watkins	Knightdale
Paige Hope Whitlow	Charlotte
Mary Louise Winters	Cary
Sidney Cullen Wright	Marshville
Jennifer Louise Young	Cary

BACHELOR OF ARTS IN SPANISH LANGUAGE AND LITERATURE

Degree Conferred August 9, 1989

Eric Morgan Thome	Richmond, VA
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Degrees Conferred December 19, 1989

†*Stefanie Anne Jernigan	Fayetteville
***Marian Davis Larrea	Cary
†***James Matthew Matson	Eden
Casimira George Rodriguez	Raleigh
***Margaret Elizabeth Thompson	Raleigh
Mary Ellen Welton	Charlotte

Degrees Conferred May 12, 1990

Annie Marie Buchanan	Raleigh
†Rebecca Louise Thompson	Greenville

BACHELOR OF ARTS IN SPEECH COMMUNICATION

Degrees Conferred June 27, 1989

Ginger Leigh Jeffords	High Point
Todd Stewart Johnson	Swansboro
Norman Randolph McArthur	Wendell
Edna Marie Robeson	Durham

Sarah Carrington Taylor	Charlotte
***Lauren Rene Thompson	Fairhope, AL
Asail Scott Tulloss	Rocky Mount
Elizabeth Williams Twohy	Richmond, VA
†Miren Karoline Zubizarreta	Caracas, Venezuela

Degrees Conferred August 9, 1989

Sam Denton III	Wendell
Mark Thomas Gill	Raleigh
William Conrad Glass	Raleigh
Cynthia Carol Hanes	Churchland
Ana Monique Kent	Raleigh
Paul Bizzell Lewis	Raleigh
Patricia Anne Lux	Cary
Jacqueline Jeanne McBride	Gastonia
Gregory Wynn Meredith	Richmond, VA
Kristy Ann Oberlander	Raleigh
Julie Ann Ostrow	Raleigh
Jeffrey Alan Peters	Raleigh
Maureen Love Reese	Kensington, MD
**Mary Kathleen Rowland	Raleigh
David Bayne Russell	Charlotte
Mary Angela Trask	Frostburg, MD

Degrees Conferred December 19, 1989

Bonita Briquette Adams	Wilson
Pamela Jean Barnes	High Point
Ashley Catherine Carter	Greensboro
Joyce Mize Carter	Raleigh
DeWitt Duncan Clark III	Clarkton
Kristin Noelle Clemmer	High Point
***Susan Watkins Davis	Oxford
Joseph Lawrence Dean, Jr.	Raleigh
Pamela Dixon	Riegelewood
Christa Marie Doiron	Seminole, FL
Christine Marie Dunsmore	Raleigh
Benjamin Thomas Ellington	Concord
Scott Benjamin Fisler	Darden, GA
Dagny Harolynn Fleming	Bennettsville, SC
Tracy Jo Floyd	Rocky Mount
Lori Melissa Fuller	Pittsburg, PA
Julia May Goodnight	Salisbury
Todd Douglas Harris	Raleigh
Layton Ballard Harwell	Statesville
Arnold Rudolph Hinshaw III	Greensboro
Bryan Reeves Hoffman	Southern Pines
Wiley Anson Howard	Fuquay-Varina
Vanessa Johnson	Enfield
Charles Clifford Jones, Jr.	Apex
Kimberly Laura Kees	Eden
Aulet Kilpatrick	Winterville
Kassandra Lynette Love	Shelby
†Tiffany Paige Martz	Durham
Karen Antoinette McCall	Fayetteville
Daren Lee McLamb	Dunn
Kevin Patrick McLaughlin	Charlotte
Floyd Rudy Mills, Jr.	Garner
*Catherine Lee Moeschet	Raleigh

† Co-major * Cum Laude ** Magna Cum Laude *** Summa Cum Laude H Honors Program

Suzanne Christina Myers	Raleigh
Allison Maria O'Neill	Hendersonville
Joseph William Sellers, Jr.	Kings Mountain
Keshia Shiver	Brooklyn, NY
Frances Michelle Slaughter	Jacksonville
†Edward Evans Smallwood	Durham
Charles Hunter Warner III	Savannah, GA
Michael John Wenhart	Raleigh
Mary Margaret West	Concord
Benjamin Hicks Whitaker	Franklinton
Melody Faith Williams	Rocky Mount
*David Elliott Wilson	High Point
Sonia Renee Wylie	Denver

Degrees Conferred May 12, 1990

Christopher Edward Adams	Parkton
Kathryn Wright Albrecht	Raleigh
Dawn Byrd Andrews	Durham
Kimberly Ann Ayer	Tallahassee, FL
Michael Carlo Barbee	Raleigh
Deborah Nerissa Bertrand	Brooklyn, NY
Christina Marie Blandi	Pittsburgh, PA
*Julie Anne Bradford	Springhill, LA
Kristin Burns Bradley	Springfield, VA
Scott Allan Brennan	Fayetteville
Summylin Denean Burton	Jacksonville
Anthony Guy Cacciarelli	West Bloomfield, MI
Philip John Patrick Campion	Raleigh
Glenn Dale Capel	Candor
Dale Anne Carter	Winston-Salem
Michelle Anne Charlesworth	Raleigh
Carla Jean Cobb	Burlington
Robin Lynn Crabtree	Hillsborough
Adrina Elizabeth Crichlow	Wyandanch, NY
Melinda Sheryl Cummings	Greensboro
William Francis Daly	Raleigh
Matthew Douglas Davis	Raleigh
Audrey Bernail Dawson	Vanceboro
Della Kay Dennis	Southern Pines
*Kristin Diane Doyle	Raleigh
Angela Marie Drye	Winston-Salem
Lisa Kim Floyd	Thomasville
***Joseph Thomas Gaitens	Cary
***Veronica Lynn Gibbs	Fayetteville
Gene Ray Gilmore	Fayetteville
Michael Raymond Given	Millburn, NJ
Joseph Scott Glass	Raleigh
Corwin Green	Amherst, MA
Eric Joseph Greene	Asheville
Susan Lane Greene	Star
Lisa Ann Guion	Aurora
Lance Robert Hammond	Jefferson, OH
Kathryn Elizabeth Hardee	Apex
Amy Shue Hays	Garner
Edmond Michael Heelan, Jr.	Greensboro
Robert Vance Helms	Advance
Kerri Lynn Hobbs	Mount Laurel, NJ
Jennifer Marie Holland	Lincolnton

† Co-major * Cum Laude ** Magna Cum Laude *** Summa Cum Laude H Honors Program

Wayne Russell Holland	Charlotte
Sherry Louise Honey	Concord
Trina Lane Hoover	Asheville
Burke Conrad Hutcheson	Chapel Hill
Andr� Romon Hyde	Fayetteville
Mark Steven Inman	Durham
Kirsten Jill Jenkins	Winston-Salem
Randall Keith Justice	Goldsboro
*Eleanor Doreen Kibler	Charlotte
Angela Denise Kirk	Winston-Salem
*William Erik Kramer	Woodland Hills, CA
Kit Lam	Hong Kong
Martha Elizabeth Lien	Charlotte
Melissa Hope Liles	Bailey
Darryl Stephon Lomick	Bessemer City
*Celia Lynn Lucas	Raleigh
†Billy Dal Maddalon	Charlotte
Eric Scott Mangrum	Upper Marlboro, MD
Kelli McNeil March	Cary
Rodney Taylor Martin	Martinsville, VA
Robert Lynn McCann	Raleigh
Brian Andrew McDonald	Birmingham, AL
Sally Lynn Miller	Raleigh
Kathryn Adrienne Millikan	Gainesville, GA
William Michael Milstead	Statesville
Kelly Elizabeth Mizell	Charlotte
Tracy Cecelia Mollura	Paoli, PA
Mary Kandace Morris	Elizabeth City
Monique Deneice Morris	Spring Valley, NY
Margaret Elizabeth Morrison	Charlotte
*Kyoko Murakami	Tottori, Japan
Eva Mae Murphy	Lewiston
*Lori Lynn Murray	Fayetteville
Gina Elizabeth Newell	Charlotte
Michele Lee Noll	Binghamton, NY
Holly Ann Nye	Raleigh
Thomas Martin Ollis	Stanfield
Patrice Kay Paul	San Francisco, CA
***Jeannie Marie Pegg	Marshall
Susan Elizabeth Powell	Charlotte
James Michael Propst	Raleigh
Steven Charles Prue	Greensboro
Thomas Astor Ramsey	Shelby
Mary Patricia Reilly	Springfield, IL
*Genette Lynn Robinson	Greensboro
Joseph Wesley Saundercook	Raleigh
Tracy Elizabeth Savage	Charlotte
*Beth Ellen Schnackenberg	Milwaukee, WI
Michele Chablis Schramm	Raleigh
*Kimberly Ann Schubert	Asheville
Melanie Shi Stogner	Raleigh
Chris Anne Summey	Hendersonville
Kimberly Ann Surles	Fayetteville
Frederick Murrill Sylvester	Emerald Isle
Jeanie Elleanor Taft	Raleigh
Robert Glenn Townsend III	Raeford
Wendy Leigh Weatherman	Lumberton
Wade Jason Whitney	Columbia, MD
David Clark Wilk	Raleigh

† Co-major

* Cum Laude

** Magna Cum Laude

*** Summa Cum Laude

H Honors Program

*Jean Marie Woessner	Stewartville, MN
William Michael Woods	Raleigh
Michael David Wright	Zebulon
Richard Mark Zanfardino	Myrtle Beach, SC
Timothy A. Zettel	Raleigh

BACHELOR OF SOCIAL WORK

Degrees Conferred June 27, 1989

Suzanne Carol Mallard	Raleigh
**Suzanne Olivia Miller	Potomac, MD

Degrees Conferred August 9, 1989

Darlene Dunay Dosio	Beacon, NY
Sarah Louise Newton	Greenville

Degrees Conferred December 19, 1989

Kimberly Ann Clayton	Pinehurst
Laura Susan Comer	Raleigh
***Verna Arthur Edwards	New Bern
Christina Marina Mejian	Raleigh
Melinda Moxin	Raleigh
Derek Roan Proctor	Rocky Mount
**Margaret Burden Seagroves	Cary
Andrea Nell Shrum	Shelby
Crystal Hope Whichard	Bath

Degrees Conferred May 12, 1990

Regina Ann Erhard	Rockaway Beach, NY
*Felix C. Germuth	Fayetteville
*Jodi Kristen Hall	Raleigh
†Kara Eileen Heizer	Chapel Hill
*Barbara Linda Levy	Raleigh
H***Cheryl Hawkins Theriault	Raleigh

College of Physical and Mathematical Sciences



BACHELOR OF ARTS IN CHEMISTRY

Degrees Conferred June 27, 1989

William Frank Kauder III	Greensboro
†William Scott Troutman	Florence, SC
***Pamela Emmanuele Wisniewski	Wake Forest

† Co-major

* Cum Laude

** Magna Cum Laude

*** Summa Cum Laude

H Honors Program

Degree Conferred August 9, 1989

†Wendy Earle Ryals Raleigh

Degrees Conferred December 19, 1989

James Michael Bowers Raleigh
†Robert Franklyn Burke Raleigh
Richard Clark Crowell Wilmington
Charles Tracey Lancaster Goldsboro
John Thomas McLean Lenoir
Rhonda Lynn Mullis Matthews
Andrew Scott Russell Cary

Degrees To Be Conferred May 12, 1990

H†**James Lester Barbee IV Hamlet
†***Robert Kevin Blackburn Roseboro
†William Earl Blackwell, Jr. Greensboro
Kathryne Alicia Brewington Greensboro
***Michael Francis Buckley Durham
†**William Edward Burton III Conover
***David Alston Chesnutt Turkey
†Ted C Davis Overland Park, KS
H†**Michelle Lynne DuBois Dallas, TX
†**Alston Elmo Dunbar III Pantego
†Robin Elaine Freeman Columbia, SC
†Dennis William Hall Garner
†Wendy Noble Jefferson Behhaven
Glenda Rene Jones Monroe
†Sharon Renee Lingle Raleigh
Christopher Todd Lowden Charlotte
Amy Michelle McCormick Greensboro
*John Marcus McManus Fayetteville
†Christopher David Parks Winston-Salem
Kristina Lynn Robinson Newton
H†***Arles Allen Taylor Carthage
***Lori Renée Toth Cary
†Karen Michelle Winningham Winston-Salem
David Francis Worsley, Jr. Garner

BACHELOR OF SCIENCE IN CHEMISTRY

Degree Conferred August 9, 1989

Samuel Craig McClintock Raleigh

Degrees Conferred December 19, 1989

Whitney Stephen Averill Portsmouth, NH
**Jerry Wayne Clark Wake Forest
Steven Frederick Klose Raleigh
Timothy Tyler Skelding Burke, VA
John David Wallwork High Point
Stuart Wayne Woods Hendersonville

Degrees Conferred May 12, 1990

Michael Griffith Bartlett Raleigh
***Deborah Marie Berg Raleigh
**Johan Bo Bergenholtz Raleigh
Charles Scott Brent Winston-Salem

† Co-major * Cum Laude ** Magna Cum Laude *** Summa Cum Laude H Honors Program

Robert Loren Bridges	Riverside, CA
LeighAnne Carroll	Colmar, PA
H†**Sung Jin Cho	Raleigh
Karen Elizabeth Fearington	Raleigh
Donald Rinehart Hagge III	Raleigh
Peter Hennessy Kariher	Greensboro
H***Krista Kasdorf-Connard	Charleston, WV
H**Susan Ellen Kuharcik	Wilmington
†Kelly Ann Mace	Pinnacle
Dewey Granville McCafferty	Raleigh
Antoinette Eugenia Pence	Raleigh
Kurt Gregory Reinbold	Fairfax Station, VA
Stephen Eric Slaughter	Maiden
Steven Alexandra Wilson	Mamers

BACHELOR OF ARTS IN GEOLOGY

Degrees Conferred December 19, 1989

H*Jerry Lee Burgess, Jr.	Rock Creek, WV
Stephen McRae Holmes	Bowdens
Randy Joel Pulley	Kittrell
Angela Michelle Sanderson	Raleigh

Degrees Conferred May 12, 1990

Stephen Andrew Hall	Louisburg
Edward Anderson Hull II	Charlotte

BACHELOR OF SCIENCE IN GEOLOGY

Degree Conferred August 9, 1989

Angela Teresa Daniels	Wilmington
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Degree Conferred December 19, 1989

Peter Sean Boyles	Cary
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BACHELOR OF SCIENCE IN MATHEMATICS

Degree Conferred June 27, 1989

Michael Wade McMullin	Havelock
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Degrees Conferred August 9, 1989

Richard Wark Cohan	Charlotte
**Margery Leigh Hollis	Charlotte
**Keiko Hoshino Suzuki	Tokyo, Japan

Degrees Conferred December 19, 1989

*Rachel Anne Bodner	Marietta, GA
Patricia Ann Gunter	Winston-Salem
Bessie Renee Hubbard	Fuquay-Varina
Syamala Ponnappalli Kasichainula	Raleigh
*Hok Kim	Seoul, Korea
John Vernon Logan	Wilson
Joseph James Morrocco IV	Elon College
***Laurie Ann Ryba	Garner
David Andrew Spears	Mars Hill
John Louis Von Hagen	Greensboro
*Roger Scott Yates	Denton

† Co-major * Cum Laude ** Magna Cum Laude *** Summa Cum Laude H Honors Program

Degrees Conferred May 12, 1990

Lisa Ann Barcomb	Raleigh
Bryant Lewis Barnhardt	Burlington
Janis Merle Bigler	Potomac, MD
Lisa LaTonya Dixon	Garner
David Phillip Edwards III	Fayetteville
**Jerome Eric Estoye	Roanoke Rapids
†**Paula Berry Frazier	Fayetteville
*Scott Thomas Gray	Raleigh
*Melissa Raye Grimes	Kenly
Richard Earle Hallbeck, Jr.	Candler
Fred Leo Heller	Raleigh
†**Stephen David Hench	Raleigh
Christopher Kemp Horne	High Point
Stuart Rex Jefferys	Kernersville
Laurie Lynn Overman	Kitty Hawk
†**Malinda Jane Piland	Mebane
David Forrest Simmons	Lumberton
*Dolly Denise Smith	Mooreville
Dustin Patrick Smith	Vass
***Candace Ruth Somers	Long Beach
David Sherman Torain II	Hillsborough
William Leonard Turner	Jacksonville
James Anthony Viegas	Bloomsbury, NJ
Mary Frances Williams	Raleigh
H*David Reid Wilson	Charlotte
Jason Gray Yeomans	Marshallberg

BACHELOR OF SCIENCE IN METEOROLOGY

Degrees Conferred June 27, 1989

Stephen Allen Burrus	Kinston
Raymond Allison Winstead III	Enfield

Degree Conferred August 9, 1989

Charles William Hale II	Tarboro
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Degrees Conferred December 19, 1989

H***Mototaka Nakamura	Yamaguchi City, Japan
Richard Ray Simpson	New Bern
Jeffrey Douglas Stewart	Burlington

Degrees Conferred May 12, 1990

Andrea Ann Adams	Alexandria, VA
H*Randall Jamil Alliss	Norfolk, VA
H Henry Thomas Bulluck	Rocky Mount
H***Joseph Jerome Cione	Montgomery, NY
Douglas Edwin Outlaw	Bishopville, SC
H Jeffrey Matthew Vukovich	Raleigh
H*Sharon Lynn Watkins	Raleigh

BACHELOR OF SCIENCE IN PHYSICS

Degrees Conferred August 9, 1989

†Christopher Walon Apple	Greensboro
--------------------------------	------------

+ Co-major

* Cum Laude

** Magna Cum Laude

*** Summa Cum Laude

H Honors Program

Degrees Conferred December 19, 1989

***Charles John Brabec	Raleigh
Robert Ludwig Tucker	Raleigh

Degrees Conferred May 12, 1990

**Joffa Michele Applegate	New Bern
H***Michael Jennings Bennett	Columbus, OH
Rodney Craig Bloom	Browns Mills, NJ
H***Judith Elaine Bush	Raleigh
Jon Eric Carnes	Raleigh
**Cari Beth Carothers	Mebane
H***Darin Thomas Cox	Raleigh
†***David Brian Eason	Durham
John David Grovenstein	Raleigh
H**Paul Reece Huffman	Winston-Salem
**Lewis Elgin Johnson	Raleigh
William David Jones	Rockingham
H**Amitabh Mohan	Kanpur, India
**Gregory John Newman	Davidson
John Roy Retelle	Ft. Wayne, IN
John Wesley Stuart	New Bern
H*Shannon Elizabeth Wells	Winston-Salem

BACHELOR OF SCIENCE IN STATISTICS

Degree Conferred August 9, 1989

Tiawanda Michele Allen	Washington, DC
------------------------------	----------------

Degrees Conferred December 19, 1989

Susan Houle Cospers	Raleigh
Luther Joshua Davis III	Washington
Stephen Carl Dobbins	Burlington

Degrees Conferred May 12, 1990

William Hirschmann Haiges, Jr.	Lancaster, PA
*Jeffrey Travis Morgan	Southport
Mark Allan Tobias	Lebanon, PA

College of Textiles



BACHELOR OF SCIENCE IN TEXTILE ENGINEERING

Jointly administered by the College of Textiles and the College of Engineering.

Degrees Conferred December 19, 1989

Robert Jay Bender	Fayetteville
†Stephan Max Bolliger	Spartanburg, SC

Degrees Conferred May 12, 1990

*Jinan Glasgow Bennett	Raleigh
Sherry Leslie Coonse	Granite Falls
*Nancy MarcheLe Evans	Wilson
Jennifer Rae Hash	Hope Mills
Brian Cletus Huss	Lincolnton
John Paul Knorr	Raleigh
Arleen Michelle McCoy	Goldsboro
John Timothy Roberts	Burlington
Robert Thomas Snyder, Jr.	Wilmington
†**Jane Elizabeth Stover	Charlotte

BACHELOR OF SCIENCE IN TEXTILE CHEMISTRY

Degree Conferred August 9, 1989

Richard Hart Fairfield, Jr.	Greensboro
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Degrees Conferred December 19, 1989

Douglas Jorge Cevdar	Tupelo, MS
James Garry Hough	Wadesboro
†Andrew Robert Romano	Greensboro

Degrees Conferred May 12, 1990

†Sandra Annette Bridges	Lawndale
Donald Wade Burgess	Gibsonville
Randi Ann Muir	Raleigh
John Charles Norton	Wingate
†Thomas Dieter Rathke	Charlotte
†***Steven Wayne Smith	Waynesville

BACHELOR OF SCIENCE IN TEXTILE AND APPAREL MANAGEMENT

Degrees Conferred June 27, 1989

Virginia Christine Galloway	Greenville
Charles Franklin Hollar	Newton

Degrees Conferred August 9, 1989

Michael Lynn Jones	Apex
***Aaron Edward Lintz	Madison
Carol Ann Presswood	High Point

† Co-major * Cum Laude ** Magna Cum Laude *** Summa Cum Laude H Honors Program

Degrees Conferred December 19, 1989

Richard Gennaro Adesso	Raleigh
Alan Frank Albright	Burlington
Heinz Erich Altmann	Kannapolis
†Stephan Max Bolliger	Spartanburg
*Leah Rene Caviness	Lakeview
Lenwood Davis, Jr.	St. Pauls
Jeffrey Thomas Dixon	Farmville
**Paul Thomas Garner	Greensboro
Gary Conrad Haines	Charlotte
Kevin Lane Howerton	Burlington
Scott Andrew Matre	Charlotte
Peter Uwe Mekailian	Encino, CA
Christopher Ellis Raynor	Beulaville
Quintin Lee Shuler	Gastonia
William Edward St. Pierre	Charlotte
Bruce Dale Weaver, Jr.	High Point
Larry Daniel Worrell, Jr.	Goldsboro

Degrees Conferred May 12, 1990

Johnnie Lynn Beasley	Henderson
Scott Anthony Bennett	Garner
Wendy Carol Blackwelder	Salisbury
Charles William Bolick III	Salisbury
Kenneth Gregory Bryant	Asheboro
Eugene Kittrell Butler	Axton, VA
Andrew Worth Cox	Ramseur
Jennifer Jill Denton	Raleigh
Michael Chun Duncan	Greenville
Robert Eugene Earp	Raleigh
Laura Elizabeth Faggart	Concord
Bret Harold Fisher	Charlotte
Charles Homer Flynt III	Greensboro
Robert Sean Gorman	Raleigh
James Milton Guy	Raeford
Amy Marie Hawkins	Hickory
Kentley Brian Hester	Gastonia
Michael Gregory Hook	Bessemer City
Donald Verner Horn II	Bessemer City
Harold Richard Hunnicutt III	Gastonia
**Anthony Scott Ingle	Hendersonville
Jeffrey Scott Johnson	Lowell
*Leslie Elizabeth Kausch	Clemmons
David Eugene Lee, Jr.	Benson
Randall Dean Matthews	Stokesdale
Graham Currie McCormick	Lumberton
Michael William Pereira	Bayboro
Bernadine Pitts	Fayetteville
Christopher Brian Rains	Elon College
**Carrie Schurecht	Barrington, IL
Anne Warden Sinkler	Memphis, TN
**Jennifer Lyn Smith	Laurinburg
**Suzanne Denise Smith	Charlotte
Julie Elizabeth Stevens	Mount Airy
**Ann Renée Stout	Burlington
Michaela Coggins Stout	High Point
***David Oliver Strickland	Willow Spring
Gregory Taylor Warren	Gastonia
Julienne Linnette Willetts	Boliva

† Co-major * Cum Laude ** Magna Cum Laude *** Summa Cum Laude H Honors Program

BACHELOR OF SCIENCE IN TEXTILE SCIENCE

Degree Conferred June 27, 1989

Charles Douglas Kale Asheville

Degrees Conferred August 9, 1989

Maria Costa Demetriou Nicosia, Cyprus
James Kevin Martin Yadkinville

Degree Conferred December 19, 1989

Wiley Thomas Mayo III Farmville

Degrees Conferred May 12, 1990

†Sandra Annette Bridges Lawndale
**Michael David Carruthers, Jr. Durham
Dinh Uyen Tan Hickory
†Cirrelia Raye Thaxton Newport News, VA
†Keith Davis Westbrook Fayetteville

BACHELOR OF SCIENCE IN TEXTILES

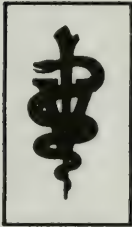
Degrees Conferred December 19, 1989

Wendy Lee Christian Midlothian, VA
Radford Barnard Davis Raleigh

Degrees Conferred May 12, 1990

*Kim Suzanne Anderson Charlotte
Melissa Anne Boring Fletcher
Timothy David Sutton Clark Greensboro
Kimberly Lynn Davis Lumberton
Andrea Patrice DeLapp Concord
Ronald Keith Guyton Fayetteville
Bryan Keith Hutchens Sandy Ridge
Frank Laurier LaMontagne Henderson
Sherry Kaye Patterson Mount Olive
Luis Enrique Quevedo San Jose, Costa Rica
***Susan Barnett Sawyer Raleigh
Aida Semunegus Raleigh
Beth Adaire Sigmon Hickory
Lisa Deanna Smith Burlington
†Cirrelia Raye Thaxton Newport News, VA
Nancy Lea Turner Raleigh
†Keith Davis Westbrook Fayetteville
Sara Elizabeth White Greenville

DOCTOR OF VETERINARY MEDICINE



COLLEGE OF VETERINARY MEDICINE

Degrees Conferred May 12, 1990

Mary McMullan Alexander	Huntersville
David Edgar Anderson	Oak Ridge
Paul Sabetay Bencuya	Raleigh
Louis Duncan Beretich	Clinton
Joel Kirk Budd, Jr.	Sanford
Karen Marie Bulluck	Battleboro
Charles Marshall Coats	Rocky Mount
Stanley Cameron Corbin	Greensboro
John Jay Cox III	Chapel Hill
Susan Marie Dermer	Cary
Diana Whittier Dudley	Durham
Jack Gregory Gallagher	Raleigh
Anna Marie Gallo	Raleigh
Phyllis Ann Gensheimer	Raleigh
Barry Thomas George	King
Patsy Potter Gilliam	Grifton
Kristie Lee Gingery	Raleigh
Cheryl Renee Pope Goodwin	Winston-Salem
Glenn Larson Gray	Gastonia
Robert Samuel Hanes, Jr.	Raleigh
Lisa Ann Harrenstien	Raleigh
John Berry Harvey	Tryon
Bethany Dawn Heidler	Moorestown, NJ
Susanne Alicia Hughes	Snow Hill
Sue Ann Hurlbert	Cary
Elizabeth Elaine Jordan	Elizabeth City
Sandra Anne Justis	Concord
Ralph Augustus Keel, Jr.	Flat Swamp
Carol Marie Kelly	Cary
Jennifer Leadbetter Kingsley	Chapel Hill
Howard Sherman Krovetz	Raleigh
Julie Carol Lawrence	Colerain
Adrienne Otto Lee	Chapel Hill
Lorraine Overcash Linn	Monroe
Barry Dail Little	Durham
Jacqueline Locklear	Rowland
Mary Hope Lucas	Wilson
Karen Lynn Manuel	Winston-Salem
Eve Pinkham Mills	Raleigh
Sally Jane Moore	Wilmington
Amy Poteat Moye	Rutherfordton
Paula Louise Nelson	Chapel Hill
Patricia Lynne Niehm	Raleigh
Clint Townsend Nygaard	Rowland

† Co-major * Cum Laude ** Magna Cum Laude *** Summa Cum Laude H Honors Program

Michael Wayne Overton	Oxford
Daniel John Petrus	Atco, NJ
Mark André Plott	Raleigh
Forrest Ross Rich	Durham
Lynne Joyce Riley	Raleigh
Grady Leon Robbins III	Winston-Salem
Ruth Morton Roberts	Fletcher
Noreen Marie Roche	Raleigh
William Ezra Rodgers III	Eden
Frank John Rutowski	Fuquay-Varina
Steven Lee Schindler	Zebulon
Steven Robert Shackelford	Chapel Hill
Harry Owen Snelson	Asheville
Faye Marie Sparks	Raleigh
Melody Claire Speck	Hampstead
Rhonda Yvonne Vega	Raleigh
Robin Colletta Waters	Mount Airy

† Co-major

* Cum Laude

** Magna Cum Laude

*** Summa Cum Laude

H Honors Program

GRADUATE DEGREES

Master's Degrees



MASTER OF AGRICULTURE

Degree Conferred August 9, 1989

Eric Nelson Caldwell Winston-Salem

Degrees Conferred December 19, 1989

James Ralph Britt, Jr. Mount Olive
Roger Neal Cobb Liberty
Edwin Lewis Phillips, Jr. Greensboro

Candidates for Degree May 12, 1990

Eduardo Ruben Secanell Reconquista, Argentina
Reuben Mitchell Smith Oak City

MASTER OF ARCHITECTURE

Degrees Conferred December 19, 1989

Azad Atashi Tehran, Iran
Andrew James Iatridis Tenafly, NJ
Phillip Reid Kiester Raleigh
Kyle Evan Troxell Winston-Salem
Peter McDearmon Witt Durham

Candidates for Degree May 12, 1990

Sarah Duncan Drake Pittsboro
Bradley Gale Ensz Rapid City, SD
Bradley Wayne Farlow High Point
Diane Helen Filipowicz Manchester, NH
Donna Joy Globus Trenton, NJ
John McLean Jordan, Jr. Saxapahaw
Charles Roland Kelsey Ridgewood, NJ
Michael Ross Kersting Las Cruces, NM
Ana Castro Lipscomb Montgomery, AL
Nathan Glen Maune Little Rock, AR
Geoffrey Neil Sifrin Savoy, South Africa
Katherine Louise Somers Healdsburg, CA
Elias John Torre Bloomfield Hills, MI
Steven Marcelo Urena Raleigh
Indrata Wangsaputra Jakarta, Indonesia

MASTER OF BIOLOGICAL AND AGRICULTURAL ENGINEERING

**Candidate for Degree May 12, 1990*

Iftikhar Ahmad Gujranwala, Pakistan

MASTER OF CHEMICAL ENGINEERING

Candidate for Degree May 12, 1990

Brian Dean Phenix Gulfport, MS

MASTER OF CHEMISTRY

Candidate for Degree May 12, 1990

Patrick Daniel Blacha Blackwood, NJ

MASTER OF CIVIL ENGINEERING

Degrees Conferred August 9, 1989

Roy Tilman Barker Oxford
Ying-Chih Chiu Taichung, Taiwan, Republic of China
Lynn Watson Evans Greenville
Ming Kao Taipei, Taiwan, Republic of China

Degrees Conferred December 19, 1989

James Ralph Batts, Jr. Cary
Nya Kwoiti Boayue Bundadin, Liberia
Diana Lynn Browne Virginia Beach, VA
Richard Eugene Graves Center Valley, PA
Houssein Abdullah Matar Beirut, Lebanon
Dwight Anthony Pakan Raleigh
Wen-Pei Sung Taichung, Taiwan, Republic of China

Candidates for Degree May 12, 1990

James Edward Canfield Charlotte
Hung-Shi Chen Kaohsiung, Taiwan, Republic of China
Jeffrey Charles Cole Miami, FL
Brian James Gardner Eure
Lidie Melin Green Richmond, VA
Patrick Alexander Keane Raleigh
Thomas Lee Koning Cary
Mark Etheridge Landis Cary
Karl Brian Peterson Charlotte
Humberto Adolfo Tasaico Raleigh
Billy Merle Williams, Jr. Williamson
Chenghsun Yang Taipei, Taiwan, Republic of China
Chi-Hui Yeh Kaohsiung, Taiwan, Republic of China

MASTER OF COMPUTER ENGINEERING

Degrees Conferred December 19, 1989

Shyh-Cheng Chuang Taipei, Taiwan, Republic of China
Terry MinYih Wang Taipei, Taiwan, Republic of China
Sz-Hung Yang Taipei, Taiwan, Republic of China

MASTER OF COMPUTER SCIENCE

Candidates for Degree May 12, 1990

Ching-Jye Chang Taichung, Taiwan, Republic of China
Robert Steven Coats Durham
Mary Elizabeth Drexler Raleigh
Jui-Fen Huang Taipei, Taiwan, Republic of China
Elizabeth Carsten Langston Cary
Yoshiko Shozuka Tokyo, Japan.
Lien-Chi Yu Taipei, Taiwan, Republic of China

MASTER OF COMPUTER STUDIES

Degrees Conferred August 9, 1989

Tao-Chiung Chi	Taipei, Taiwan, Republic of China
Keh-Chen Sun	Taipei, Taiwan, Republic of China
Angela Ruth Teachey	Rose Hill
Jie Fu Wang	Canton, People's Republic of China
Shugang Yeh	Beijing, People's Republic of China

Degrees Conferred December 19, 1989

Sanjay Narsinva Matange	New Delhi, India
Richard James Spangler	Jefferson, WI
Donald Edward Weber	Raleigh

Candidate for Degree May 12, 1990

Yeh-Hung Chou	Taipei, Taiwan, Republic of China
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MASTER OF ECONOMICS

Degrees Conferred August 9, 1989

Niv Bauch	Haifa, Israel
Jirong Wang	Xian, People's Republic of China
Margaret Mahoney Wohlgenant	Cary

Degrees Conferred December 19, 1989

Bonnie Green Barrett	Raleigh
Mas Achmad Daniri	Jakarta, Indonesia

Candidates for Degree May 12, 1990

Carl Wayne Bundy	Raeford
Koichiro Hata	Osaka, Japan
Keith Fox Reed	Raleigh
John Lawrence Sorrels	Raleigh

MASTER OF EDUCATION

Adult and Community College Education

Degrees Conferred August 9, 1989

Ned Everett Delamar	Oriental
Pamela Jean Youngs-Maher	Pulaski, NY

Degrees Conferred December 19, 1989

Morris Jerome Dunn	Kinston
Janice Langdon Hastings	Raleigh
Michael Eugene Regans	Charlotte

Candidates for Degree May 12, 1990

Stephanie Jean Arneth	Cary
Betty Privott Dail	Edenton
Billy Gordon Green, Jr.	Raleigh
Donna Atwood Hunt	Sparta
Liane Elizabeth Salmon	Smiths Falls, Ontario, Canada
Naomi Priscilla Slifkin	Chapel Hill
Mark Thomas Taylor	Somersworth, NH
Herman Joseph Wright	Roseboro

Agricultural Education

Degree Conferred December 19, 1989

John Ray Davis, Jr. Louisburg

Candidates for Degree May 12, 1990

Lisa Yvette Bryan Bladenboro
Wiley Jones Loflin, Jr. Denton
Beasley Berry Strickland Tabor City
Dewey Craig Waddell Fair Bluff

Curriculum and Instruction

Degrees Conferred August 9, 1989

Madeline May Allen Troy
Peggy Morgan Douglas Chapel Hill

Degrees Conferred December 19, 1989

Nancy Kenyon Crowley Raleigh
Margaret Jordan Todd Raleigh
Barbara Russell von Biberstein Burgaw

Candidates for Degree May 12, 1990

Lois Cobb Clement Birmingham, AL
Cheryl Jean DeBurkarte Stem
Joanne Elizabeth Glassford Raleigh
Louise Watson Lamm Bailey
John Edward Rothenberg, Jr. Raleigh
Melody Anne Helms Sears Charlotte
Deborah Blake Swain Cary
Jo Murphree Szontagh Cary

Educational Administration and Supervision

Degrees Conferred December 19, 1989

Vera Jane Palmer Warrenton
William Herbert Stocks Hookerton

Candidates for Degree May 12, 1990

Richard Rorex Losch Wilmington
Joan Owens Pierson Raleigh
Patricia Hampton Wiltshire Cary

Educational Administration and Supervision: Higher Education

Degrees Conferred August 9, 1989

Holly June Huso Aneta, ND
Kristopher Jerome Kaase Marietta, GA

Candidates for Degree May 12, 1990

Virginia Janet McDonald Cary
Mark Milton Pieters Newark, NY

Guidance and Personnel Services

Degrees Conferred August 9, 1989

Stephen Michael Blake Kingstree, SC
Patricia Ann Rainey Frazier Henderson
Alexandra Marie Jepson Raleigh

Degrees Conferred December 19, 1989

Robertson Williams Buck, Jr.	Raleigh
Susan Parler Hobbs	Raleigh
Teresa Louise Lineback	Cary
Barbara Hale Rhudy	Raleigh

Candidates for Degree May 12, 1990

Frankye Bynum Artis	Raleigh
Clifford Jay Doehring	Ferndale, MI
Pamela Pomeroy Erwin	Raleigh
Kathryn Durushin Kesler	Raleigh
June Marie Merlino	Durham
Mary Alice Tetro	Washington, DC

Mathematics Education

Degree Conferred August 9, 1989

Susan Oddo Redmond	Charlotte
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Candidates for Degree May 12, 1990

John Richard Griggs	Apex
Jennifer Lynn Oligee	Taylor Mill, KY

Middle Grades Education

Degrees Conferred December 19, 1989

Sandra Jane Satterfield Henegar	Zebulon
Sally Fowler Holloman	Durham

Candidate for Degree May 12, 1990

Caroline Jackson Lassiter	Raleigh
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Occupational Education

Degrees Conferred August 9, 1989

Lee Brown Jackson	Fremont
Jearline Harris Spence	Fort Barnwell

Degree Conferred December 19, 1989

Jacqueline Renee Powell	Raleigh
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Candidates for Degree May 12, 1990

Brenda Faye McCord Bish	Raleigh
Michael James Guerrero	Raleigh
Barbara Ann Kirkpatrick	Raleigh
Judith Tolson Lassiter	Wendell

Science Education

Degree Conferred December 19, 1989

Catherine McCluskey	Raleigh
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Candidates for Degree May 12, 1990

Jennifer Lee Andrews	Raleigh
Julia Dunning Cameron	Raleigh

Special Education

Degrees Conferred August 9, 1989

Ana Campbell Atwater	Raleigh
Paula Hickman Crawford	Raleigh
Lauren Brehm Henry	Raleigh
Wendy Denise Parker	Pfafftown
Lorraine Petkus	North Haledon, NJ
Frances Lynne Evans Walker	Raleigh

Degrees Conferred December 19, 1989

Michele Antonetti	Burgettstown, PA
Vaun Marie Tschieder	Raleigh
Ann Elizabeth Tyrey	Durham

Candidates for Degree May 12, 1990

Carole Elizabeth Mills Church	Morrisville
Kari Kamile Criswell	Cary
Mary Froese Enns	Raleigh
Linda Louise Leaver	Apex
Marian Elliott Looney	Kingsport, TN
Dorothy Lungen Meyer	Raleigh
Virginia Kosec Powell	Philadelphia, PA
Elizabeth Ann Majors Smith	Raleigh

Training and Development

Candidate for Degree May 12, 1990

*Walter Nowell Perry III	Raleigh
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MASTER OF ENGINEERING

Degrees Conferred December 19, 1989

Charles Eckner Graham, Jr.	Greensboro
Linh Hai Luong	Winston-Salem
Charles Brent Spencer	Newton

Candidates for Degree May 12, 1990

Stephen Paul Broadhead	Greenville
John McRee Davidson	Swannanoa
Glenn Thomas Haller	Asheville
Donald Elwood Marsh	Newark Valley, NY
William McCoy	Wilmington
Jerome James Reid	Greensboro
Catherine Collins Smith	Mooreville, IN
Robert Melvyn Thomas	Washington
Douglas Vaughn Wood	Xenia, OH

MASTER OF FORESTRY

Candidates for Degree May 12, 1990

William Mark Danuck	Raleigh
José Luis Romero	Cali, Colombia

(*Co-major in Public Affairs)

MASTER OF INDUSTRIAL ENGINEERING

Degree Conferred December 19, 1989

James Lee Penry High Point

MASTER OF INTEGRATED MANUFACTURING SYSTEMS ENGINEERING

Degree Conferred August 9, 1989

Carroll Gray Perkins Pilot Mountain

Degrees Conferred December 19, 1989

Chih-Chung Chen Taipei, Taiwan, Republic of China
Lee Paul Colbert Silver Spring, MD
Jason Keith Ruppert New Orleans, LA
Andreas Iacovos Savva Nicosia, Cyprus
Larry Edwin Smith, Jr. Taylorville, IL
Paul Hoi-Sui Wong Raleigh

Candidates for Degree May 12, 1990

James Andrew Grant Charlotte
Douglas Duff Greenwood Raleigh
Djohan Halima Medan, Indonesia
Ching-Lin Pan Shanghai, People's Republic of China
Kao-Kai Shaw Taipei, Taiwan, Republic of China
Michael Robert Spano Apex

MASTER OF LANDSCAPE ARCHITECTURE

Degrees Conferred December 19, 1989

Stephen Scott Bernard Toledo, OH
Paula Kay DeVille Cary
Brooks Haislip Gage Raleigh
Patricia Kearny Katz Atlanta, GA

Candidates for Degree May 12, 1990

Julia Haynsworth Barringer Florence, SC
Mark St. John Clapp Fayetteville
Scott Richard Griess Elmhurst, IL
Vernon Lee Carson Hershberger Columbia, SC
John Seaton Ives Woodbridge, CT
Peter Truesdell Lucey Raleigh
Timothy William Maloney Raleigh
Wendy Leone Olson Merced, CA
Joanne Benton Rubino Baltimore, MD
Catherine Jane Panning Voorhees Durham

MASTER OF LIFE SCIENCES

Degree Conferred August 9, 1989

Anne Derrien La Baule, France

Candidates for Degree May 12, 1990

Gwen Elizabeth Bullock Roxboro
Jorge Del Rio Lares, Puerto Rico
Sayyaparaju Madhusudana Raju Hyderabad, India

MASTER OF MATERIALS SCIENCE AND ENGINEERING

Degree Conferred December 19, 1989

David Phillip Malta Raleigh

Candidates for Degree May 12, 1990

Frank Fong-Kai Lee Shantong, People's Republic of China
Safaa Sabry Said Cairo, Egypt

MASTER OF MECHANICAL ENGINEERING

Degrees Conferred December 19, 1989

Kwanho Choi Seoul, Korea
Michael Henry Van Haaren Epse, The Netherlands

Candidates for Degree May 12, 1990

Mark Edward Marler Charleston, SC
Vipul Bhadrakumar Sheth Baroda, India

MASTER OF NUCLEAR ENGINEERING

Degree Conferred August 9, 1989

John Bernard Waters Mount Prospect, IL

Degrees Conferred December 19, 1989

Shounak Madhusudan Athavale Pune, India
Ker-Chung Ching Taipei, Taiwan, Republic of China
Scott Wilson Moser Kannapolis

MASTER OF PRODUCT DESIGN

Degrees Conferred August 9, 1989

Sophie Kumm Burkheimer Bahama
Victoria Ko-Jye Chi Taipei, Taiwan, Republic of China
Alice Io Oglesby Putney, VT
Brian James Scott Seattle, WA
Julia Borden Stout Denver, CO
Patricia Leigh Tommerdahl Benson

Degree Conferred December 19, 1989

Jacqueline Gertrud Wheelaghan Edinburgh, Scotland

Candidates for Degree May 12, 1990

Max Justin Beck Raleigh
Margaret Elizabeth Callery Pottsville, PA
Susan Key Settergren Durham
Richard Chase Stone Deerfield, IL
Lisa Ellen Wollman Raleigh

MASTER OF PUBLIC AFFAIRS

Degrees Conferred August 9, 1989

Jennifer Lynn Alexander Columbia, SC
James Brookshire Bradshaw Wilson
Samuel Harold Chambers South Boston, VA
Kyle Purdom Fay Winston-Salem

Malcolm Andrew Frazier	Woodstock, VA
Gerardette Marita Furlow	Hampton, VA
Wayne Green	Richmond, VA
Roberta Anne Leighton	Brevard
Andrew McEachern	Raeford
Carol Ward Parker	Greensboro
David Edouard Marcel Patte	Nashville, TN
Dee Wynn Worden	Raleigh
Lisa Maria Wright	Raleigh

Degrees Conferred December 19, 1989

Alana Minette Ennis	Durham
Thomas Vance Holloman	Raleigh

Candidates for Degree May 12, 1990

Richard Evan Best	Old Tappan, NJ
Barbara Bolton DuRant	Oxford
Stephen John Gurganus	Raleigh
Jonathan Fonati Koffa	Raleigh
Laura Lynn McClain	Cary
John Stephen Ramey	Raleigh
Timothy Kyle Robinson	Wilmington
John Joseph Sandy	Parkersburg, WV
Elizabeth Neal Shipp	Fayetteville
Diana Nicklas Staley	Lock Haven, PA
Leigh Ann Weathers	Raleigh
Debra Joan West	High Point

MASTER OF RECREATION RESOURCES ADMINISTRATION

Degree Conferred August 9, 1989

*Carol Elizabeth Trost	Marquette, MI
------------------------------	---------------

Candidates for Degree May 12, 1990

Janie Ruffin Albergotti	Norfolk, VA
*Sherry Lee Crose	Cincinnati, OH
Kenneth Randall Forrest	Poquoson, VA
*Timothy Ray Johnson	Smithfield
*Jill Kristine Krantz	Oregon, WI
*Terry Lee Patterson	Covington, VA
Cynthia Leigh Summer	Cherryville

MASTER OF SOCIOLOGY

Candidates for Degree May 12, 1990

Kimberly Gray Croom	Littleton
Johnny Tuan Noyes	Fayetteville

MASTER OF STATISTICS

Degree Conferred August 9, 1989

Jose Francisco Pastrana-Zuniga	San Jose, Costa Rica
--------------------------------------	----------------------

Degrees Conferred December 19, 1989

Richard Allen Bynum	Goldsboro
Robert Scott Cone	Tulsa, OK
Cynthia Anne Rodenberg	Cincinnati, OH
Stephen Joseph Shack	Raleigh

(*Co-major: Public Affairs)

Candidates for Degree May 12, 1990

Chai Ni Chang	Taipei, Taiwan, Republic of China
Richard York Davies	Staten Island, NY
William Robert Gould	Bozeman, MT
Julia Clare Graz	Omaha, NE
William Louis Kendall	Cincinnati, OH
Susan Melissa Starr	Weaver, AL

MASTER OF TEXTILES

Degrees Conferred August 9, 1989

Pinakin Dattatray Chaubal	Bombay, India
Giorgio Marco McBeath	Cleveland, OH
John Carver Standish	Loudonville, NY

Degree Conferred December 19, 1989

Rebecca Ann Mumaw	Mansfield, OH
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Candidate for Degree May 12, 1990

Daniel William Khoury	Montreal, Quebec, Canada
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Master of Arts Degrees



Archival Management

Candidates for Degree May 12, 1990

Eric Eugene Jackson	Leesburg, VA
Laura Ann Marino	Raleigh
Sandra Denise Moore	Elkin
James Mark Valsame	Garner

English

Degrees Conferred August 9, 1989

Sharon Marie Barrell	New Orleans, LA
Rosemary Del Fava Hallberg	Wake Forest
Phyllis Arrington Stephens	Milan, NY
Lucindy Alderson Willis	Shreveport, LA
Debra Lee Hancock Wolfe	Rock Hill, SC

† Co-major

* Cum Laude

** Magna Cum Laude

*** Summa Cum Laude

H Honors Program

Degrees Conferred December 19, 1989

Brian Mark Blackley	Raleigh
Anthony Victor Grausso	Raleigh
Clifford Maxwell Green	Raleigh
Kenneth Wayne Norris	Birmingham, AL
Debbie Hutchinson Oxendine	Maxton
David Warren Wilson	Raleigh

Candidates for Degree May 12, 1990

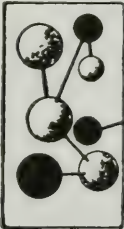
Patricia Janice Brasher	Raleigh
Perry Cameron Cumbie	Durham
John Gregg Cusick	Chapel Hill
Daun Daemon	Hudson
Peggy Marie Goodwin	Apex
Angeletta Kim Marie Gourdine	Charleston, SC
Laura Doles Ritchie	Williamsburg, VA
Kathryn Patricia Roe	Cary
Edward Alan Shannon	Park Ridge, NJ
June Tunfo Chang Tung	Raleigh

History

Degrees Conferred August 9, 1989

Margaret Scott Chrisawn	Greenville
James Scott Humphreys	Kinston

Master of Science Degrees



Adult and Community College Education

Degree Conferred December 19, 1989

Monica Lynne Mitchell	Pittsboro
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Candidate for Degree May 12, 1990

Dale Adams O'Neal	Raleigh
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Aerospace Engineering

Degrees Conferred August 9, 1989

James Robert Benton	Clemmons
Jonathon Craig McArthur	Reston, VA
James Michael Redmond	Charlotte
David William Witte	New Richmond, OH

Degrees Conferred December 19, 1989

Christopher John Fitzgerald	Redlands, CA
Francis Alphonza Greene	Hampton, VA
Susan Thomas Hudson	Bishopville
Holly Meyer Ross	Raleigh
Jeff Cartwright Taylor	Charlotte

Candidates for Degree May 12, 1990

Rusty Allan Benson	Grove City, OH
Donald Bruce Owens	Newport News, VA
Joseph Dale Simpkins	Gulfport, MS

Agricultural Economics

Degrees Conferred August 9, 1989

Linda Gail Gregory	Wilkesboro
Jorge Jose Siman	San Salvadore, El Salvadore

Degrees Conferred December 19, 1989

Grace Victoria Chomo	Raleigh
Luis Pedro Cussianovich	Lima, Peru

Agricultural Education

Candidate for Degree May 12, 1990

Evelyn McAdams Browning	Efland
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Animal Science

Degree Conferred August 9, 1989

Rebecca Lynn Krisher	Fairfield, OH
----------------------------	---------------

Biochemistry

Degree Conferred August 9, 1989

Wiley Forbus Betts	Raleigh
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Biological and Agricultural Engineering

Degrees Conferred December 19, 1989

Susan Glass Capps	Charlotte
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Botany

Degree Conferred December 19, 1989

Teresa Carla Mularoni	Old Greenwich, CT
-----------------------------	-------------------

Chemical Engineering

Degree Conferred August 9, 1989

Scott David Soltis	Sarasota, FL
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Degree Conferred December 19, 1989

Charles Michael Hamilton	Charlotte
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Candidate for Degree May 12, 1990

David Michael Razmus	Ellicott City, MD
----------------------------	-------------------

Chemistry

Degrees Conferred August 9, 1989

William Dale Carter, Jr.	Southport
Nada Farah Samaha	Raleigh

Degree Conferred December 19, 1989

William H. Reiss	Huntington, NY
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Candidate for Degree May 12, 1990

Vinitha Senaratne	Colombo, Sir Lanka
-------------------------	--------------------

Civil Engineering

Degree Conferred August 9, 1989

David Wayne Bramlett	Raleigh
----------------------------	---------

Degrees Conferred December 19, 1989

William Edgar Lee, Jr.	Fernandina Beach, FL
Sharon Annette Milstead	Charlotte
Alan Louis Stone	Bassett, VA

Candidates for Degree May 12, 1990

Peter Olayinka Adeleke-Sheidun	Benin City, Nigeria
Maher Georges Jabre	Beruit, Lebanon

Computer Engineering

Degrees Conferred August 9, 1989

Rajesh Abbi	New Delhi, India
Syed P. F. Ahmed	Raleigh
Geoffrey Abbott Allen	Pleasantville, NY
Caglan Mahmet Aras	Ankara, Turkey
Todd Alan Cook	Huntsville, AL
Wayne Carroll Gordon	North Jay, ME
Russell Stephenson Greer	Starkville, MS
Yong-Hee Jeon	Kyungbuk, Korea
Edward Michael Kaiser	Cary
Denise Ann Skroch	Raleigh
David Walter Thomas	Jasper

Degrees Conferred December 19, 1989

Janne Y. Abullarade	Raleigh
Randy Lee Cramp	Maple Shade, NJ
William Charles DeStein	Cary
Howard Donald Gage	Durham
Shrikant Ali Rangnekar	Bombay, India
Clayton Owen Shy	Raleigh

Candidates for Degree May 12, 1990

Kevin Greg Gunter	Santa Ana, CA
Tan Thanh Duy Phan	Fayetteville
Mark Baron Rauschenberger	Raleigh
Robert Stockton Ray	Raleigh
David Keith Smith	Orlando, FL
Douglas Alan Thomaе	Mequan, WI

Computer Science

Degrees Conferred December 19, 1989

Brenda Faye Crutchfield	Camden, AL
Jayesh Vrajajal Ghia	Bombay, India
Jerry Lewis Pietenpol	Raleigh
Steven Eric Polge	Huntsville, AL
Wei Wu	Taipei, Taiwan, Republic of China

Candidates for Degree May 12, 1990

Ajay Madhusudan Athavale	Pune, India
Joann Marie Jennings	Raleigh
Amitkumar Manoharrao Paradkar	Badlapur, India

Computer Studies

Degrees Conferred August 9, 1989

Marshall David Brian	Zebulon
Edward Dean Holloman	Wilson

Degree Conferred December 19, 1989

Theodore Edwin Brooks, Jr.	Raleigh
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Crop Science

Degrees Conferred August 9, 1989

Uta Grieshammer	Verden, West Germany
Gail Elaine Mahnken	Frohna, MO
David Vaughn Uhr	Palatka, FL
Steven Frank Vozzo	Pompton Lakes, NJ
Martha Cameron Willcox	Winston-Salem
Zhimin Wu	Shanghai, People's Republic of China

Degree Conferred December 19, 1989

James Latham Hodges, Jr.	Washington
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Candidates for Degree May 12, 1990

Ann Lynette Low	Denver, CO
Jeana Lynn Myers	St. Albans, WV
Thomas Anthony Tucker	Greensboro

Curriculum and Instruction

Candidate for Degree May 12, 1990

Debora Miller Barton	Raleigh
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Ecology

Degree Conferred December 19, 1989

John Nuncie Sacco	Linwood, NJ
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Candidate for Degree May 12, 1990

Susan Mae Braxton	Raleigh
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Educational Administration and Supervision

Degree Conferred December 19, 1989

Karen Irene Kitchens	Hayesville
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Electrical Engineering

Degrees Conferred August 9, 1989

Apirux Bantukul	Bangkok, Thailand
Nita Johnson Byrd	Raleigh
Stephen Thomas Cochran	Columbia, MO
Jorge Alberto Dada	San Salvadore, El Salvadore
George George	Bangalore, India
Ronald Morris Holdaway	Richmond, VA
Ross Boyd Leavens	Galion, OH
Thomas Richard Neal	Glen Burnie, MD
Uzma Rehana Siddiqi	Raleigh
Blaine Allen Stackhouse	Charlottesville, VA
Aslihan Tumer	Ankara, Turkey

Degrees Conferred December 19, 1989

Wael Ahmad Al-Qaq	Silwan, Palestine
Robert Bruce Ash	Alma, WV
Steven Langley Blake	Denville, NJ
Mark Alan Bodenheimer	Knoxville, TN
Leonard Allan Bush	Raleigh
Miguel Eduardo Chavez	Lima, Peru
Gregory Keith Daugherty	Burlington
Alice Faye Forgety	Raleigh
Stephen Joseph Garnier	Kankakee, IL
John Thomas Gatsis	Raleigh
Montague Ernest Hardy III	LaGrange
Wade Eric Jackson	Florence, SC
Jeyhan Karaoguz	Raleigh
Hongseog Kim	Seoul, Korea
Subash Krishnankutty	Madras, India
Ivan Francisco Matulic	Sucre, Bolivia
Surajit Bapi Mukkerjee	Newark, DE
John Mark Mullen	Wake Forest
Amir Pirzadeh	Tehran, Iran
Michael LeRoy Riddle	Raleigh
Terrence James Riley	New Castle, PA
George William Schuman II	Saint Joseph, MO
David Beardsley Slater, Jr.	Raleigh
Arild Fuldseth Sundet	Trondheim, Norway
Jeffrey Lynn Timbs	Elizabethton, TN
Todd Michael Venema	Wheaton, IL

Candidates for Degree May 12, 1990

Jari Yrjo Arppe	Kokkola, Finland
Ugar Celikkan	Ankara, Turkey
Brian Walker Coughlan	Henderson
Cem Mehmet Dogrusoz	Ankara, Turkey
Donna Lynne Flora	Orlando, FL
Peter William Gollmar	Durham
Walter Eastburn Greene	Pontiac, MI
James Charles Hall	Cincinnati, OH
Craig Alan Hamilton	Bainbridge, GA
Deanne Wilson Isbell	Raleigh
Mark David Lamb	Milford, NH
Lorraine Elizabeth Lambert	Virginia Beach, VA
Karl Thomas Leinfelder	Chapel Hill
José Luis Medero	Carolina, Puerto Rico
William Leland Pribble	Lynchburg, VA
Valaiyakarani C. Ramesh	Madras, India

Dewey Samuel Roberts II	Sanford
Mark Allen Scoville	Wheaton, MD
Peter Michael Shea	Camden, SC
Michael Reid Slawson	Knoxville, TN
Richard Dean Suffridge	Raleigh
Larry Thomas	Wayne, PA
Thomas Aaron Winslow	Troutman
James Steven Worley	Greenville
Dahua Zhang	Beijing, People's Republic of China

Entomology

Degrees Conferred August 9, 1989

Cheng-I Chien	Taipei, Taiwan, Republic of China
Christopher David Harlow	Lafayette, IN
Stuart Henry McKamey	Santa Rose, CA

Degree Conferred December 19, 1989

William Lanier Nicholson, Jr.	Hiawassee, GA
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Candidates for Degree May 12, 1990

Christopher Dale Campbell	Lake Forest, IL
Michael Ralph Zeiss	Redington Beach, FL

Food Science

Degrees Conferred December 19, 1989

Constance Ann Caugherty-O'Neil	Vandergrift, PA
Julia Ellen Erickson	Corvallis, OR
Jeff Wayne Liebrecht	Delphos, OH

Candidates for Degree May 12, 1990

Patricia Ruth Butcher	Kloof, South Africa
Fatima Lisette Canjura	Guatemala City, Guatemala

Forestry

Degree Conferred August 9, 1989

Andrew Karl Wolgemuth	State College, PA
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Degrees Conferred December 19, 1989

Hans Paul Ehler	Park Ridge, IL
Juan Bernardo Jurado-Blanco	Maracay, Venezuela
Keith Fox Reed	Raleigh

Candidates for Degree May 12, 1990

Timothee Nembot Fomete	Dschang, Cameroon
Ann Hu	Changdu, People's Republic of China
Maria Pilar Zaldivar Garcia	Burgos, Spain

Guidance and Personnel Services

Candidate for Degree May 12, 1990

Jerry Ronald Sprague	Raleigh
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Horticultural Science

Degrees Conferred August 9, 1989

David Franklin Ruff	Hendersonville
Johan Marcel Stoop	Tervuren, Belgium

Degrees Conferred December 19, 1989

Gene Braxton Cross	Wake Forest
William Henry McCarthy	Birmingham, MI

Candidate for Degree May 12, 1990

Leslie Anne Bjelk	Sunnyvale, CA
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Industrial Engineering

Degrees Conferred August 9, 1989

Sandeep Jaisingh Agarwal	Ahmedabad, India
Hsien-Lian Chou	Stanford, CA
Jong-Shin Liao	Taipei, Taiwan, Republic of China
Atthakorn Losong	Petchiburi, Thailand
Jacqueline Lee Reynolds	North Greenbush, NY
Rosalina Martin Rodriguez	Raleigh
Russell James Sojourner	Colorado Springs, CO

Degrees Conferred December 19, 1989

Krishna Kishore Ginpupalli	Visayawada, India
Shieng-Chyuaru Jang	Taipei, Taiwan, Republic of China
Charles Grant McKee	Durham
Darren Eugene Morris	Raleigh

Candidates for Degree May 12, 1990

Claude Swanson Graves III	Washington
Donna Jo Lauretta	Elmira, NY
Scott Jay Scherbenske	Falls Church, VA
Cecil Eilton Stackhouse, Jr.	Siler City

Management

Degrees Conferred August 9, 1989

Denise Carol Byrd	Chase City, VA
Hsi-mei Chen	Taipei, Taiwan, Republic of China
Jone-Yeu Yang	Chunan, Taiwan, Republic of China

Degrees Conferred December 19, 1989

Joel Edward Battiste	Durham
Ching-Fei Chuang	Taipei, Taiwan, Republic of China
Gonzalo Jose Clemente	Caracas, Venezuela
Walter Fletcher Kelly, Jr.	Raleigh

Candidates for Degree May 12, 1990

Karen Leigh Chapman	Winston-Salem
John Anthony Esparza	Durham
Deborah Lynn Harner	Akron, OH
Rahul Madhav Joshi	Bombay, India
Scott Parker Liggett	Pittsburgh, PA
Katty Ooms	Leuven, Belgium
Tarek Ahmad Saadi	Amman, Jordan
Samuel Paul Stephenson	McGee's Crossroads
Mohammad Ahmad Syed	Meerut, India
Tsuey Jiuan Wu	Taichung, Taipei, Republic of China

Marine, Earth and Atmospheric Sciences

Degrees Conferred August 9, 1989

Michael Edward Adams	Milford, CT
William Henry Bauman III	Ossining, NY
Ronald Lester Dunic	Pittsburgh, PA
John Mark Egentowich	Hinsdale, IL
Bernard Joseph Genna	Medford, NY
Malay Jindal	Roorkee, U.P., India
Lawrence Dennis Moy	Chapel Hill
James deNoyon Pattee	Vestal, NY
Dale Robert Perry	Wichita, KS

Degrees Conferred December 19, 1989

Stephen Lowell Harden	Columbia, SC
Ajay Kumar	Raleigh
Laura Ann Nye	Akron, OH
Matthew James Parker	Charlotte
Jeffrey Chia-en Tsai	Raleigh

Candidates for Degree May 12, 1990

Constance Anne Crossley	New York, NY
Daniel Michael Eisenstein	Sicklerville, NJ
Marsha Carol Kinley	Dallas
Jeffrey William Martin	Wintersville, OH
Joseph Piazzola	Raleigh
Rose Angela Ragnacci	Trenton, NJ
Andrew Leigh Wachob	Buffalo, NY
Edmund Woloszyn, Jr.	North Versailles, PA

Materials Science and Engineering

Degrees Conferred August 9, 1989

Alan Todd Parsons	Hickory
Elizabeth Foster Smith	Mocksville

Degrees Conferred December 19, 1989

Cheryl Diane Davis	Goldsboro
Mark David Fisher	Raleigh
George Thomas Goudey	Raleigh
Laxman Muruges	Visakhapatnam, India
Rita Kimari Prasad	Raleigh
Takeshi Tachibana	Osaka, Japan
Vasudev Venkatesan	Madras, India

Candidates for Degree May 12, 1990

John Peter Bade, Jr.	Hopewell Junction, NY
Winston Scott Blackley	Wilmington
James Timothy Kelliher	Somerville, MA
John Gilford Pellerin	Hollywood, FL
James Mark Roberts	Raleigh

Mathematics (Applied)

Degrees Conferred August 9, 1989

Mihail Angelidis	Athens, Greece
Laura Anne Britt	Raleigh
Young-Soog Hyun	Seoul, Korea

Degrees Conferred December 19, 1989

Laric Eugene Copes	Beaufort
Terri Lynn Kammerer	Pittsburgh, PA
Jinhyo Kim	Seoul, Korea

Candidates for Degree May 12, 1990

Wanda Keturah Anderson	Columbia, SC
Webb Lewis Burgess	Raleigh
Thierry Jean-Pierre Chaussalet	Besancon, France
David Lee Chinkes	Raleigh
John Russell Taylor	Rocky Mount
Li Wang	Shanghai, People's Republic of China

Mechanical Engineering

Degrees Conferred August 9, 1989

David Allen Grigg	Charlotte
Michael Hung-Tai Luh	Raleigh

Degrees Conferred December 19, 1989

Langdon Stanford Bennett	Raleigh
Joseph Dean Drescher	Harrisonburg, VA
Charles Patrick Eakes	Greensboro
Jonathan Richard Hamilton	Gloucester
Charles Alan McKeel	Princeton
Junergen Panoscha	Tryon

Candidates for Degree May 12, 1990

William Chris Eaton	Advance
John Adams Harris	Clarksville, VA
Randy Alan Hight	Franklinton
Frank Middleton Mungo	Pageland, SC
Vicki Lynn Owen	Smithfield

Microbiology

Degrees Conferred August 9, 1989

Scott Reynolds Jeffrey	Richmond, VA
Susan Rose Lanning	Raleigh
David Ewell Slade	Raleigh

Degrees Conferred December 19, 1989

David Allen Freeman	Garner
Mary Elizabeth Mainous	Norton, VA
April Alison Smith	Reynoldsville, PA

Candidates for Degree May 12, 1990

John Shields Morris	Asheville
David Franklin Pence	Raleigh

Nuclear Engineering

Degrees Conferred December 19, 1989

Seung-Jae Han	Seoul, Korea
Roger Lee Thomas, Jr.	Greensboro

Candidates for Degree May 12, 1990

Richard Herman Rustad	Aiken, SC
Sairaju Tallavarjula	Visakhapatnam, India

Nutrition

Degree Conferred August 9, 1989

Christopher Andrew BowieCovington, GA

Degree Conferred December 19, 1989

Clay Alan ZimmermanWalkersville, MD

Candidates for Degree May 12, 1990

Joel Leslie Johnson Morrisville

Donald William KelemenCharlotte

Occupational Education

Degree Conferred December 19, 1989

Theodore Joseph Branoff Cary

Operations Research

Degree Conferred August 9, 1989

Tawfik Ali GadAlexandria, Egypt

Candidate for Degree May 12, 1990

Hassan Ashraf Allouba Cary

Physics

Degrees Conferred December 19, 1989

William Scott Enloe Edneyville

Yvonne Marie LeGrice Jacksonville

Michael William Thelander Norfolk, VA

Physiology

Degree Conferred August 9, 1989

Janet Lynn Fisher Belle Center, OH

Degrees Conferred December 19, 1989

Carol Beth Goetze Raleigh

Jacqueline Umstead Johnson Raleigh

Sherry Lynn Sinclair Clinton

Candidates for Degree May 12, 1990

Eric Robert Jones Gibsonburg, OH

Dean Edward Morbeck Milwaukee, WI

Steven Gary Wolfe Raleigh

Karen Alisa Fry Zimmerman Annandale, VA

Plant Pathology

Degree Conferred August 9, 1989

Brian Charles Eshenaur Harrisburg, PA

Degree Conferred December 19, 1989

Patricia Jo Dudash Avon Lake, OH

Psychology

Degrees Conferred August 9, 1989

Thomas Stanton Brugler	Toledo, OH
Sandra Louise Miller	Marietta, GA
James Russell Peeler	White Sulphur Springs, WV

Degrees Conferred December 19, 1989

Sylvia Yvonne Bittle	Charlotte
Lycia Anne Carter	Cambridge, MA
Frederick Scott Hunter Krauss	Waynesville

Candidates for Degree May 12, 1990

Copper MacKenzie Coggins	Asheville
Renee Louise Mercer	Charlotte

Recreation Resources Administration

Degree Conferred August 9, 1989

Jonelle Scott Nuckolls	Baltimore, MD
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Degree Conferred December 19, 1989

Juikun Kuo	Tainan, Taiwan, Republic of China
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Candidates for Degree May 12, 1990

Claude Horace Ellington, Jr.	Washington
David Andrew Holdstock	Nottingham, England
Laurie Elaine Loker	Mt. Brydges, Ontario, Canada
Elizabeth Tess Luman	St. Louis, MO

Rural Sociology

Candidates for Degree May 12, 1990

Arnold Steven Bell	Fayetteville
Matthew Virgil Pruitt	Bowling Green, KY

Science Education

Degree Conferred December 19, 1989

Alice Davis Anderson	Wilmington
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Soil Science

Degree Conferred August 9, 1989

Robert Carl Freese	Holden, MA
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Degrees Conferred December 19, 1989

Fahmuddin Agus	West Sumatra, Indonesia
Ralph Michael Coolman	Menomonee Falls, WI
David Frederick Weymann	LaCanada, CA

Textile Chemistry

Degree Conferred August 9, 1989

Jiunn-Yow Chen	Taichung, Taiwan, Republic of China
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Degree Conferred December 19, 1989

Timothy Winfield Towell	Towaco, NJ
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Candidates for Degree May 12, 1990

Joseph Franklin Hotter	Cary
Charles Clayton Sloop III	Concord

Textiles

Degrees Conferred August 9, 1989

Pau-Lin Chen	Taipei, Taiwan, Republic of China
Elizabeth Ann Moore	Riverview, MI

Degrees Conferred December 19, 1989

Kathleen Davis Batton	Pueblo, CO
Pravin Dhundiraj Gangal	Thana, India
Hyojin Kim	Allentown, PA
Alan Lowell Price	Belleville, KS

Candidates for Degree May 12, 1990

Robert Emerson Allison, Jr.	Cleveland
Jong-Ju Kim	Seoul, Korea
Lana Michele Poffenroth	Calgary, Alberta, Canada
Simon Dele Senibi	Kabba, Nigeria

Toxicology

Degree Conferred December 19, 1989

Linda Jeanne Schmidt	Oriskany, NY
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Candidates for Degree May 12, 1990

Scott Oliver Knowles	St. Petersburg, FL
David Anthony Tulis	Raleigh

Veterinary Medical Sciences

Candidate for Degree May 12, 1990

John Richard Dodam	Raleigh
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Vocational Industrial Education

Degree Conferred December 19, 1989

Alex James Procter	Rocky Mount
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Wildlife Biology

Degree Conferred August 9, 1989

Laura Jeanette Mitchell	Greensboro
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Degree Conferred December 19, 1989

Victor Ricardo Doig	Ormond Beach, FL
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Candidate for Degree May 12, 1990

Alton Emory Kinlaw	Eustis, FL
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Wood and Paper Science

Degrees Conferred December 19, 1989

Mohamad Jamil Abuhasan	Perak, Malaysia
Carol Diane Bronsdon	Issaquah, WA

Zoology

Degree Conferred August 9, 1989

Deborah Elspeth Young Blacksburg, VA

Degrees Conferred December 19, 1989

Karen Marie Kracko Albuquerque, NM
Gerald Brian Pottern Springfield, MA

Doctor of Education Degrees

Degrees Conferred August 9, 1989

David Elwood Aman, Curriculum and Instruction
Jacksonville, North Carolina

Dissertation: Choosing Schools of Choice: An Ethnographic Study of How Parents Choose Magnet Schools for Their Children. (Under the direction of Barbara M. Parramore.)

Linda Dale Briggs, Adult and Community College Education
Butner, North Carolina

Dissertation: AIDS Education on the Streets: Perspectives on Educating the Alienated. (Under the direction of Arlene Fingeret.)

Donald Wayne Cobb, Adult and Community College Education
Henderson, North Carolina

Dissertation: Leadership Effectiveness on County Extension Directors: A Comparison of Perceptions between County Extension Agents and County Extension Directors within the North Carolina Agricultural Extension Service. (Under the direction of R. David Mustian.)

Pamela Ballance Edwards, Occupational Education
Kenly, North Carolina

Dissertation: Continuing Education Needs Perceived by North Carolina Associate Degree, Diploma and Baccalaureate Degree Registered Nurses. (Under the direction of Joseph R. Clary and Ruth M. Patterson.)

Lula Whichard Everett, Adult and Community College Education
Greenville, North Carolina

Dissertation: Factors That Contribute to Stepfather-Stepchild Relationships. (Under the direction of Arlene Fingeret.)

Victoria Ann Foster, Guidance and Personnel Services
Raleigh, North Carolina

Dissertation: Adolescent and Young Adult Females Making an Abortion Decision: A Profile of Ego and Moral Development. (Under the direction of Norman A. Sprinthall.)

Aldine Kieffer Guthrie, Adult and Community College Education
Greenville, North Carolina

Dissertation: Factors That Influence Management Styles of Hospital Chief Executive Officers in North Carolina Hospitals. (Under the direction of J. Conrad Glass, Jr.)

Gloria Ann Lindsay, Guidance and Personnel Services
Spindale, North Carolina

Dissertation: Promoting the Development of High-risk College Students through a Deliberate Psychological Education-based Freshman Orientation Program—A Follow-up Study. (Under the direction of Don C. Locke.)

Ottis Lilburn Murray, Jr., Adult and Community College Education
Pembroke, North Carolina

Dissertation: An Examination of Low Income Farmworker's Participation in a CETA Program in Robeson County, North Carolina: A Search for Variables Related to Training and Employment Success. (Under the direction of J. Conrad Glass, Jr.)

Joye Alice Norris, Guidance and Personnel Services

Raleigh, North Carolina

Dissertation: The Relationship between the Conceptual Levels of Adult Basic Education Students and Performance on the Tests of Adult Basic Education (TABE). (Under the direction of Norman A. Sprinthall and Arlene Fingeret.)

Rhonda Hefner Patterson, Guidance and Personnel Services

Raleigh, North Carolina

Dissertation: The Effect of Relationship Skills Training on the Moral and Cognitive Development and Empathic Responding of Parents. (Under the direction of Don C. Locke and Debie D. Saidla.)

Ernestine Brown Small, Adult and Community College Education

Greensboro, North Carolina

Dissertation: Factors Associated with Political Participation of Nurses. (Under the direction of Ronald W. Shearon.)

Florence Currie Taylor, Adult and Community College Education

Kenansville, North Carolina

Dissertation: Adult Basic Education Directors' Perceptions of the Impact of Curriculum Level Funding on Adult Basic Education in North Carolina. (Under the direction of Arlene Fingeret.)

Degree Conferred December 19, 1989

David Carroll Jeffiers, Adult and Community College Education

Taylorsville, Kentucky

Dissertation: Factors Associated with Adult 4-H Volunteers' Evaluation of Life Skills Development among Participants in the Kentucky 4-H Program. (Under the direction of Edgar J. Boone.)

Candidates for Degree May 12, 1990

Elazer James Barnette, Industrial Arts Education

Cramerton, North Carolina

Dissertation: The Identification of the Major Concepts That Define Technological Literacy for Precollege Education. (Under the direction of V. William DeLuca and Richard E. Peterson.)

Mary Elizabeth Beckner, Adult and Community College Education

Hagerstown, Maryland

Dissertation: Factors Affecting the Learning of Altruistic Values by Adults: A Case Study in a Medical Training System. (Under the direction of Arlene Fingeret.)

Brian Carson Blount, Adult and Community College Education

Greensboro, North Carolina

Dissertation: The Role of Communications Media in Decision Making: A Study of Selected North Carolina Agribusiness Chief Executive Officers and Their Perceptions of Communication Media. (Under the direction of R. David Mustian.)

Irene Adams Brownlee, Adult and Community College Education

Durham, North Carolina

Dissertation: Profile of Women Students in North Carolina Community Colleges. (Under the direction of J. Conrad Glass, Jr. and Ronald W. Shearon.)

Barbara Blue Carruthers, Curriculum and Instruction
Garner, North Carolina

Dissertation: Learning Disabled Students' Achievement in the North Carolina Basic Education Plan Summer School Program. (Under the direction of Cathy L. Crossland and Bettye MacPhail-Wilcox.)

Elizabeth Hastings Conroy, Guidance and Personnel Services
Durham, North Carolina

Dissertation: A Cognitive Developmental Cross-age Tutoring Experience for Academically Gifted Fifth Graders. (Under the direction of Edwin R. Gerler, Jr. and Norman A. Sprinthall.)

Virginia Gayle Tart Davis, Adult and Community College Education
Dunn, North Carolina

Dissertation: The Relationship of Maternal Knowledge of Asthma to Control of the Child's Asthma, Maternal Perceived Uncertainty and Maternal Ability to Function in Society. (Under the direction of Ronald W. Shearon.)

Willard Stanley Garren, Occupational Education
Chocowinity, North Carolina

Dissertation: An Experimental Evaluation of Using Computer Aided Design Simulations in Teaching Basic Electronics at the College Level. (Under the direction of William J. Haynie and Richard E. Peterson.)

Rickey Lynn Garrett, Adult and Community College Education
Roxboro, North Carolina

Dissertation: Factors Associated with the Governance of State Community College Systems in the United States, 1990. (Under the direction of Edgar J. Boone.)

Robert Washington Gay, Jr., Adult and Community College Education
Raleigh, North Carolina

Dissertation: Factors Associated with Attrition among Former Part-time Adult Students at North Carolina State University, 1982-1986. (Under the direction of Edgar J. Boone.)

Regina George-Bowden, Adult and Community College Education
Durham, North Carolina

Dissertation: Academic Performance of Adults in Traditional High School Diploma Programs and High School Equivalency Certificate Programs. (Under the direction of R. David Mustian.)

Kim Felecia McPherson Greene, Occupational Education
Waycross, Georgia

Dissertation: Perceived Barriers toward College Enrollment of African American High School Seniors. (Under the direction of Joseph R. Clary and James L. Flowers.)

Russell Clayborn King, Adult and Community College Education
Wise, North Carolina

Dissertation: Attitudes of North Carolina Tobacco Producers toward Tobacco Production and Marketing: A Study of Factors That Affect Continued Production. (Under the direction of R. David Mustian.)

Pamela Allison Klute, Occupational Education
Mishawaka, Indiana

Dissertation: The Effects of Supportive Mailings on Smoking Reduction Levels in Smoking Cessation Courses. (Under the direction of Gary E. Moore.)

Paul Lee Leeland, Adult and Community College Education
Washington, North Carolina

Dissertation: Effect of Participation in the Clinical Pastoral Education Program upon Level of Moral Development among Clergy. (Under the direction of Ronald W. Shearon.)

Larry Eugene Price, Occupational Education
Middlesex, North Carolina

Dissertation: Attitudes of School Administrators in the Southern Region of the United States toward Agriculture Education. (Under the direction of Larry R. Jewell.)

Alan Keith Ray, Adult and Community College Education
Waynesville, North Carolina

Dissertation: Assessment of Learning Outcomes in Non-credit Continuing Education and Training: A Status Study. (Under the direction of Grover J. Andrews and J. Conrad Glass, Jr.)

Roger Dale Safrit, Adult and Community College Education
Salisbury, North Carolina

Dissertation: Values Clarification in the Strategies Planning Process of an Adult Education Organization. (Under the direction of Edgar J. Boone.)

Barry Wayne Saunders, Adult and Community College Education
Roxboro, North Carolina

Dissertation: The Relationships between Job Status, In-service Training and Specified Job Outcomes among Highway Maintenance Workers in the North Carolina Department of Transportation. (Under the direction of Ronald W. Shearon.)

Peggy Sue Dupree Smith, Curriculum and Instruction
Angier, North Carolina

Dissertation: Planning, Implementing and Maintaining a Middle School Program: A Case Study of Excellence in High Point, North Carolina. (Under the direction of John F. Arnold and Robert T. Williams.)

Jane Davis Steelman, Curriculum and Instruction
Winston-Salem, North Carolina

Dissertation: Facilitating Cognitive Development and Improving Writing Achievement of Middle Level Students through a Role-taking Experience (Newspaper) Using Computers (Word Processors). (Under the direction of Ellen S. Vasu.)

Warren Trent Strickland, Adult and Community College Education
Hamlet, North Carolina

Dissertation: A Study to Identify and Evaluate Staff Development Training Components in Locally Organized Staff Development Activities for North Carolina Public School Teachers. (Under the direction of J. Conrad Glass, Jr.)

Clyde Ray Taylor, Adult and Community College Education
Pikeville, North Carolina

Dissertation: Motivational Orientations of the Military Non-traditional Student: Attitudinal Variables Affecting Participation in Off-campus Undergraduate Degree Programs. (Under the direction of J. Conrad Glass, Jr.)

Jon Lee Wiggs, Adult and Community College Education
Wendell, North Carolina

Dissertation: Perspectives on General Education and Job Skills Training in the North Carolina Community College System: A Case Study of Organizational Policy Development. (Under the direction of Edgar J. Boone and Ben E. Fountain, Jr.)

Charlotte McDougal Wilkinson, Guidance and Personnel Services
Durham, North Carolina

Dissertation: Peer Helping: The Comparative Effects of Training and Experiential Learning on Psychological Growth of Secondary School Pupils. (Under the direction of Norman A. Sprinthall.)

Margaret Jean Prince Wittman, Guidance and Personnel Services
Greensboro, North Carolina

Dissertation: Cognitive Developmental Level and Clinical Behaviors in Occupational Therapy Students: An Exploratory Investigation. (Under the direction of Norman A. Sprinthall.)

Doctor of Philosophy Degrees

Degrees Conferred August 9, 1989

Sabit Adanur, Fiber and Polymer Science
Istanbul, Turkey

Dissertation: Dynamic Analysis of Single Nozzle Air-jet Filling Insertion. (Under the direction of Mansour H. Mohamed.)

Adedamola Akinyemi Ademoyero, Toxicology
Ile-Oluji, Nigeria

Dissertation: Description of Toxicity of Scirpenols and Lack of Interaction between Lutein and Alfatoxin in Young Broiler Chickens. (Under the direction of Pat B. Hamilton.)

Diane Gail Alston, Entomology
Montclair, California

Dissertation: Response of *Heliothis zea* (Lepidoptera: Noctuidae) and Annual Weed Populations to Soybean Growth Alterations Caused by *Heterodera glycines* (Nematoda: Heteroderidae). (Under the direction of Julius R. Bradley, Jr.)

William Frank Anderson, Crop Science
Raleigh, North Carolina

Dissertation: Early Generation Selection for Resistance to *Cercospora arachidicola* and *Cercosporidium personatum* in Peanut (*Arachis hypogaea* L.). (Under the direction of Johnny C. Wynne.)

John Michael Anthony, Physics
Cleveland, Ohio

Dissertation: Systematics of K-Auger Electron Production by 4 - 8 MeV Carbon Ions Following Collisions with Gas Targets. (Under the direction of Christopher R. Gould and Stephen M. Shafroth.)

Laura Jean Arwood, Genetics

Burlington, North Carolina

Dissertation: A Functional Approach to the Characterization of Wheat HMG Proteins. (Under the direction of Steven L. Spiker and William F. Thompson.)

Rodger Darrell Ballentine, Psychology

San Antonio, Texas

Dissertation: Numerical Classification of U. S. Air Force Enlisted Jobs: An Application of the General Work Inventory. (Under the direction of J. William Cunningham.)

Glenn Randal Bathke, Soil Science

Barnwell, South Carolina

Dissertation: Soil Physical Property Variability and Moisture Redistribution across a Dissected Piedmont Landscape. (Under the direction of D. Keith Cassel.)

John William Brown, Economics

Raleigh, North Carolina

Dissertation: An Analysis of the Economic Potential for Hybrid Striped Bass Culture. (Under the direction of James E. Easley, Jr.)

Gerald Edward Brust, Entomology

Munroe Falls, Ohio

Dissertation: Abiotic and Biotic Effects on Southern Corn Rootworm, *Diabrotica undecimpunctata howardi* Barber, Oviposition Preference, Survival and Interactions with Predators in Different Corn and Peanut Agroecosystems. (Under the direction of William V. Campbell and Fred L. Gould.)

John Dukes Byrd, Jr., Crop Science

Hartsville, South Carolina

Dissertation: Weed Interference in Cotton (*Gossypium hirsutum*) and Reciprocal Interference of Cotton Cocklebur (*Xanthium strumarium*) and Cotton. (Under the direction of Harold D. Coble.)

Ellen Schalk Casale, Biochemistry

Garner, North Carolina

Dissertation: Further Purification of Bovine Milk Gamma-glutamyl-transferase and Cellular Localization Comparisons of Sulfhydryl Oxidase and Gamma-glutamyltransferase Using Immunocytochemistry. (Under the direction of H. Robert Horton.)

Yu-Hsien Chang, Applied Mathematics

Taipei, Taiwan, Republic of China

Dissertation: Dichotomies for Abstract Reaction-Diffusion Equations. (Under the direction of Robert H. Martin, Jr.)

Tung Ching Chung, Microbiology

Taichung, Taiwan, Republic of China

Dissertation: Physiological, Genetic and Molecular Biological Studies on Production of an Antimicrobial Substance by *Lactobacillus reuteri*. (Under the direction of Walter J. Dobrogosz.)

Lane Leroy Clarke, Physiology

Shelbina, Missouri

Dissertation: Regulation of Ion Transport across the Equine Colon. (Under the direction of Robert A. Argenzio and Malcolm C. Roberts.)

Juan Jose Daboub, Industrial Engineering
San Salvadore, El Salvadore

Dissertation: Computer Aided Design of Unit Loads: An Integrated Approach. (Under the direction of John R. Canada and Jamie Trevino.)

Kristin Clark Dougherty, Psychology
Washington, DC

Dissertation: Effects of a Social Skills Training Program on the Academic Performance of Underachieving Adolescents. (Under the direction of Patricia F. Horan.)

Elizabeth Frazao, Economics
Rio de Janeiro, Brazil

Dissertation: The Value of Mother's Time and Child Nutrition: A Study in the Bical Region, the Philippines. (Under the direction of Michael K. Wohlgenant.)

Teresa Regina Gidley, Psychology
Cleveland, Ohio

Dissertation: Industry Funded Research and Graduate Engineering Education: A National Survey of Chemical and Electrical Engineering Students. (Under the direction of Denis O. Gray.)

Alexander Glenn Godfrey, Chemistry
Miami, Florida

Dissertation: The Development of α -Alkoxyorganocuprate Reagents for Organic Synthesis. (Under the direction of Russell J. Linderman and Marion L. Miles.)

Arthur Christian Grantz, Aerospace Engineering
Newport News, Virginia

Dissertation: An Approximate Viscous Shock Layer Method for Calculating the Hypersonic Flow over Blunt-nosed Bodies. (Under the direction of Fred R. DeJarnette.)

Girish Agyapall Grover, Fiber and Polymer Science
Bombay, India

Dissertation: Dynamic Measurement of Silver Properties on the Drawframe. (Under the direction of Peter R. Lord and William K. Walsh.)

Nina Estelle Heard, Chemistry
Greensboro, North Carolina

Dissertation: A Formal Synthesis of (+)-Hirsutene. (Under the direction of Samuel G. Levine.)

Joseph Raymond Heckman, Soil Science
Yorkshire, Ohio

Dissertation: Corn and Soybean Tissue Water Content, Nutrient Accumulation, Yield and Growth Pattern Responses to Potassium and Chloride Fertility Differences. (Under the direction of Eugene J. Kamprath.)

Randy H. Henson, Mechanical Engineering
Raleigh, North Carolina

Dissertation: Contact Conductance across Bolted Plates. (Under the direction of Richard R. Johnson.)

Shin Nam Hong, Computer Engineering

Seoul, Korea

Dissertation: Characterization of Ultra Shallow P⁺-N Junctions Formed by a Modified Low Energy Ion Implanter and Rapid Thermal Annealing. (Under the direction of John J. Paulos, Gary A. Ruggles and Jimmie J. Wortman.)

David Hamrick Howerton, Mechanical Engineering

Durham, North Carolina

Dissertation: An Experimental and Numerical Investigation of Orthogonal Machining of Aluminum 6061-T6. (Under the direction of John A. Bailey and John S. Strenkowski.)

Nancy Ellen Hubing, Electrical Engineering

Houston, Texas

Dissertation: Statistical Analysis of the Initialization of Recursive Least Squares Algorithms. (Under the direction of S. Thomas Alexander.)

Mohammed Ahmad Khasawseh, Electrical Engineering

Irbid, Jordan

Dissertation: Gradient Adaptive Digital Filtering: Theory and Applications. (Under the direction of Winsor E. Alexander.)

Sukil Kim, Computer Engineering

Seoul, Korea

Dissertation: The Implementation of a Parallelizing Compiler for Loosely Coupled Multiprocessor Systems. (Under the direction of Dharma P. Agrawal.)

Jae Chul Lee, Marine, Earth and Atmospheric Sciences

Seoul, Korea

Dissertation: Circulation in the Vicinity of the Shelf/Slope Front in the Mid-Atlantic Bight. (Under the direction of Leonard J. Pietrafesa.)

Laura Joan Lehman, Horticultural Science

Girard, Pennsylvania

Dissertation: Apple Tree Response to Paclobutrazol as Influenced by Scion, Rootstock and Mode of Application. (Under the direction of C. Richard Unrath and Eric Young.)

Bailian Li, Forestry

Kunming, People's Republic of China

Dissertation: Genetic Variation among Loblolly Pine Families in Seedling Growth, Root and Shoot Morphology and Nitrogen Use Efficiency, and Use of These Traits for Potential Early Genetic Selection. (Under the direction of H. Lee Allen and Steven E. McKeand.)

Hui Li, Mathematics

Wuhan, People's Republic of China

Dissertation: Rings with Infinite Sums. (Under the direction of Lung O. Chung.)

Sheikh Tahir Mahmood, Nuclear Engineering

Islamabad, Pakistan

Dissertation: Anisotropic Plastic Deformation, Formability and Crystallographic Textures of Zircaloy Sheet. (Under the direction of K. Linga Murty.)

Patricia Dayle McClellan-Green, Toxicology
Concord, North Carolina

Dissertation: Characterization and Hormonal Regulation of the Highly Polymorphic, Male-specific Cytochrome P-450g. (Under the direction of Ernest Hodgson.)

Joyce Ruth McKenzie, Chemistry
Asheville, North Carolina

Dissertation: Diastereoselective Additions of α -Alkoxyorganocuprates in Acyclic Systems. (Under the direction of Russell J. Linderman and Marion L. Miles.)

Ragab Mohamed Moheisen, Mechanical Engineering
Shebin El-Kom, Egypt

Dissertation: Thermal Contact Resistance at High Temperature for Metals in Contact. (Under the direction of Richard R. Johnson.)

Cary Allen Moskovitz, Aerospace Engineering
Greensboro, North Carolina

Dissertation: An Experimental Investigation of the Physical Mechanisms Controlling the Asymmetric Flow Past Slender Bodies at Large Angles of Attack. (Under the direction of Fred R. DeJarnette.)

Bruce Donald Mowrey, Horticultural Science
Orlando, Florida

Dissertation: Isozyme Variation and Inheritance in Peach and Other *Prunus* as Related to Taxonomic Classification and Developmental Stage. (Under the direction of James R. Ballington and Dennis J. Werner.)

Sungtae Park, Mechanical Engineering
Pusan, Korea

Dissertation: Dynamic Interactions and Globally Optimal Maneuver of Distributed Systems. (Under the direction of Larry M. Silverberg.)

Jean-Luc Rioud, Veterinary Medical Sciences
Bern, Switzerland

Dissertation: Pharmacology and Toxicology of Doxycycline in Several Species of Veterinary Interest. (Under the direction of Jim E. Riviere.)

Ruth Russell-Stern, Psychology
Cary, North Carolina

Dissertation: Early Parent Education Impact upon Mother's Attitudes, Values and Knowledge of Infant Development. (Under the direction of Samuel S. Snyder.)

Jose de Jesus Sanchez-Gonzalez, Crop Science
Jalisco, Mexico

Dissertation: Relationships among the Mexican Races of Maize. (Under the direction of Major M. Goodman.)

Kevin Donald Sarge, Biochemistry
Harrisburg, Pennsylvania

Dissertation: Intermolecular Hybridization of 5S rRNA with 18S rRNA and the Initiation of Protein Synthesis. (Under the direction of E. Stuart Maxwell.)

Hartwig Schafer, Economics
Willingshausen, West Germany

Dissertation: Real Exchange Rates and Economic Performance. The Case of Sub-Saharan Africa. (Under the direction of Paul R. Johnson and Walter N. Thurman.)

John Joseph Schemmel, Civil Engineering
Madison, Wisconsin

Dissertation: The Application of High Strength Concrete to Highway Bridges. (Under the direction of Paul Z. Zia.)

Brenda Sue Maltba Scott, Psychology
Valdese, North Carolina

Dissertation: Some Cross-system Relationships among Psychologically Relevant Occupational Constructs. (Under the direction of J. William Cunningham and Richard G. Pearson.)

Theresa Ann Smith Spencer, Economics
Raleigh, North Carolina

Dissertation: Economic Incentives for Retirement under Unionism. (Under the direction of Steven G. Allen, Robert L. Clark and Ann A. McDermed.)

Christopher Nelson Tinius, Crop Science
Fort Lauderdale, Florida

Dissertation: Mass Selection in Male-sterile Soybeans for Seed Size and Plant Dry Weight. (Under the direction of Joseph W. Burton.)

Bao Long Tsai, Botany
Taipei, Taiwan, Republic of China

Dissertation: The Fate of Glyphosate in Water Hyacinth and Its Physiological and Biochemical Influences on Growth of Algae. (Under the direction of Frederick T. Corbin and Augustus M. Witherspoon.)

Eduardo Uribe, Soil Science
Bogota, Colombia

Dissertation: Potassium Dynamics and Management in a Humid Tropical Ultisol under Low and High Input Cropping Systems. (Under the direction of Fred R. Cox.)

Tian-Yih Wang, Mechanical Engineering
Taipei, Taiwan, Republic of China

Dissertation: Approximate Analysis of Interacting Spheres and Vaporizing Droplets. (Under the direction of Clement Kleinstreuer.)

Colonel Vaughan Witten, Psychology
Fayetteville, North Carolina

Dissertation: Field Dependence-Field Independence: The Relationship of Cognitive Style and Achievement. (Under the direction of Donald W. Drewes and M. Henry Pitts.)

Kenneth Brian Wood, Chemical Engineering
Haddock, Georgia

Dissertation: Reactivity in the Radiation-initiated Cationic Copolymerization of Styrene Derivatives. (Under the direction of Vivian T. Stannett.)

Carl Herman Yung, Crop Science
Jacksonville, North Carolina

Dissertation: The Value of Gametoclonal Variation in Plant Breeding.
(Under the direction of Earl A. Wernsman.)

Jun Zhu, Genetics and Statistics
Hangzhou, People's Republic of China

Dissertation: Estimation of Genetic Variance Components in the General Mixed Model. (Under the direction of Bruce S. Weir.)

Degrees Conferred December 19, 1989

Adnan Mohammed Alattar, Electrical Engineering
Plainsboro, New Jersey

Dissertation: Knowledge-based Image Coding Technique. (Under the direction of Sarah A. Rajala.)

Khaled Hamad Al-Saqabi, Electrical Engineering
Kuwait, Kuwait

Dissertation: Extending Parallelism to Memory Hierarchies in Highly Parallel Systems. (Under the direction of Winsor E. Alexander and Edward W. Davis, Jr.)

Wallace Michael Aust, Forestry
Scooba, Mississippi

Dissertation: Abiotic Functional Changes of a Water Tupelo-Baldcypress Wetland Following Disturbance by Harvesting. (Under the direction of Russell Lea.)

Adil Eisa Awad, Crop Science
Gedarif, Sudan

Dissertation: Effects of Dicamba, Nitrogen and Presowing Hardening of Host Seed with Phenolic Acids on Witchweed Control in Sorghum. (Under the direction of Frank T. Corbin and A. Douglas Worsham.)

Jong Jin Baik, Marine, Earth and Atmospheric Sciences
Pusan, Korea

Dissertation: Tropical Cyclone Simulations with the Betts Convective Adjustment Scheme. (Under the direction of Mark DeMaria and Sethu Raman.)

Gregory Edward Bottomley, Electrical Engineering
Hockessin, Delaware

Dissertation: Roundoff Error Problems and Solutions for Conventional Recursive Least Squares Filters. (Under the direction of S. Thomas Alexander.)

Carl Joseph Braun III, Genetics
Denville, New Jersey

Dissertation: Investigation of the Texas Male-sterile Mitochondrial Genome of Maize. (Under the direction of Charles S. Levings.)

Thomas Hunter Brown, Jr., Mechanical Engineering
Raleigh, North Carolina

Dissertation: Analytic Studies on the Drying of Porous Media. (Under the direction of Michael A. Boles.)

Brian Thomas Buckley, Chemistry

Sea Girt, New Jersey

Dissertation: Sample Introduction into a Direct Current Plasma by Filament Vaporization. (Under the direction of Charles B. Boss.)

Arthur Charles Bullerwell, Fiber and Polymer Science

Raleigh, North Carolina

Dissertation: Beat-up Force in High Speed Weaving. (Under the direction of Mansour H. Mohamed.)

James Tilson Burnette, Industrial Engineering

Oak Ridge, North Carolina

Dissertation: CTD-123: A Cumulative Trauma Disorder Risk Assessment Model. (Under the direction of Mahmoud A. Ayoub and Arup Mallik.)

Wei-Di Cao, Materials Science and Engineering

Beijing, People's Republic of China

Dissertation: Effects of Electric Current and Field on the Behavior of Metallic Materials. (Under the direction of Hans Conrad.)

Daniel Ronald Caprioglio, Microbiology

Chatsworth, California

Dissertation: The Role of pSFB-1 in Secondary Metabolite Production in *Scytalidium flavo-brunneum*. (Under the direction of Leo W. Parks.)

Helen Marguerite Caprioglio, Microbiology

Eugene, Oregon

Dissertation: Membrane Sterol Localization and Response to Ethanol in the Yeast, *Saccharomyces cerevisiae*. (Under the direction of Leo W. Parks.)

James William Carson, Jr., Fiber and Polymer Science

Elkin, North Carolina

Dissertation: Synthesis of Regularly Alternating Block Copolymers Containing Amylose and Polybutadiene. (Under the direction of Richard D. Gilbert.)

Ming-Chun Chang, Statistics

Yung-Ho, Taiwan, Republic of China

Dissertation: Testing for Overdifference. (Under the direction of David A. Dickey.)

Surapong Charoenrath, Crop Science

Bangkok, Thailand

Dissertation: Inheritance of Early and Late Leafspot Resistance and Agronomic Traits in *Arachis hypogaea* L. (Under the direction of Johnny C. Wynne.)

Glenn Alford Church II, Biological and Agricultural Engineering

Ellenton, Florida

Dissertation: Flow and Energy Solution for Closed-loop Rockbed Design and Control. (Under the direction of Daniel H. Willits.)

Patrick Louis Combettes, Electrical Engineering

Paris, Frances

Dissertation: Set Theoretic Estimation in Digital Signal Processing. (Under the direction of H. Joel Trussell.)

John Robert Cook, Statistics

Des Moines, Iowa

Dissertation: Estimators for the Errors-in-variables Problem in the Ordered Categorical Regression Model. (Under the direction of Leonard A. Stefanski.)

Mohamed Yahia Dabbagh, Electrical Engineering

Aleppo, Syria

Dissertation: Multiprocessor Implementation of Two-dimensional Digital Filters for Real-time Processing. (Under the direction of Winsor E. Alexander.)

Hyun-Soo Dong, Fiber and Polymer Science

Seoul, Korea

Dissertation: Oxidative Degradation and Grafting Reaction of Hydroxyethyl Cellulose during Emulsion Polymerization of Vinyl Acetate. (Under the direction of Raymond E. Fornes and Richard D. Gilbert.)

David Lane Dreifus, Electrical Engineering

Narberth, Pennsylvania

Dissertation: The Design, Processing and Characterization of II-VI Semiconductor Devices for Infrared Optoelectronic Applications. (Under the direction of Robert M. Kolbas.)

Dorothy Dillard DuBose, Sociology

Clinton, South Carolina

Dissertation: The Effect of Reciprocity on Intergenerational Affective Solidarity. (Under the direction of Robert C. Brisson.)

Joseph David Eigel, Biological and Agricultural Engineering

Louisville, Kentucky

Dissertation: Application of Body Conforming Grids to Drainage Problems. (Under the direction of R. Wayne Skaggs and Michael D. Smolen.)

Helmut Elsenbeer, Soil Science

Kempton, West Germany

Dissertation: Hillslope Hydrological Processes and Their Controls in a Tropical Rainforest Environment. (Under the direction of D. Keith Cassel.)

Alberto Raul Escande, Plant Pathology

Mar del Plata, Argentina

Dissertation: Protection of Potato from Rhizoctonia Canker with Binucleate *Rhizoctonia* spp. (Under the direction of Eddie Echandi.)

Shihchen Fuh, Civil Engineering

Taipei, Taiwan, Republic of China

Dissertation: Applications of a Postulate of Minimum Plastic Spin in Crystal Mechanics. (Under the direction of Kerry S. Havner.)

Katherine Ann Grant, Psychology

Seattle, Washington

Dissertation: An Experimental Evaluation of a Primary Prevention Program: PREPARE. (Under the direction of Denis O. Gray.)

Marcia Lynn Gumpertz, Statistics

North Hollywood, California

Dissertation: Simple Estimators for the Linear Random Coefficient Regression Model and the Nonlinear Model with Variance Components. (Under the direction of Sastry G. Pantula and John O. Rawlings.)

Karen Greenhalgh Guzman, Biochemistry
Warwick, Rhode Island

Dissertation: Isolation and Characterization of the Gene Encoding Follicle Stimulating Hormone Beta: A Model for Negative Regulation. (Under the direction of William L. Miller.)

Do Hee Hahn, Nuclear Engineering
Seoul, Korea

Dissertation: Energy Transport through the Plasma Boundary Layer. (Under the direction of John G. Gilligan.)

Kevin Scott Hammon, Physics
Beaumont, Texas

Dissertation: The Principal Bundle of Biframes Associated with Space-time and Its Applications in General Relativity and Gauge Theories. (Under the direction of William R. Davis and Larry K. Norris.)

Salman Ul Haq, Mechanical Engineering
Islamabad, Pakistan

Dissertation: Transient Free Convection in a Fluid-saturated Porous Medium. (Under the direction of James C. Mulligan.)

Paul Joseph Hochgesang, Chemistry
Cary, North Carolina

Dissertation: Characterization of Surface Modified Electrodes Containing Polymeric Tetraazaannulene Metal Complexes. (Under the direction of Robert D. Bereman.)

Steven David Holladay, Toxicology
Raleigh, North Carolina

Dissertation: Production of Specific Antibody against Aflatoxin M₁. (Under the direction of Peter J. Bentley and Cecil F. Brownie.)

Luellen Carroll Hooks, Psychology
Dublin, North Carolina

Dissertation: Development of Adaptive Behavior in Autistic Children: Effects of Age, IQ and Degree of Autism. (Under the direction of William P. Erchul and Rachel F. Rawls.)

Harlan James Howard, Physiology
Vanderbilt, Michigan

Dissertation: Mechanisms of Extended Corpus Luteum Function in Dairy Cattle Treated with Human Chorionic Gonadotropin or Infused Continuously with Oxytocin. (Under the direction of Jack H. Britt.)

Lawrence Hoy James, Physics
Maiden, North Carolina

Dissertation: Proton Resonance Spectroscopy in ²⁹P. (Under the direction of Gary E. Mitchell.)

Hae Dong Jang, Food Science
Seoul, Korea

Dissertation: Characterization of Milk Proteins by Immobilization and Analytical Affinity Chromatography. (Under the direction of Harold E. Swaisgood.)

Shian-Ching Jason Jang, Materials Science and Engineering
Taipei, Taiwan, Republic of China

Dissertation: The Amorphization of Nickel-Aluminum Intermetallic Compounds by Mechanical Alloying. (Under the direction of Carl C. Koch.)

Adriel Duland Johnson, Animal Science
Tuskegee, Alabama

Dissertation: Characterization of an Organ Explant Culture System for the Chick Pancreas and Its Response to Nutrient and Anutrient Secretagogues. (Under the direction of William J. Croom, Jr.)

Chul Kim, Mathematics
Seoul, Korea

Dissertation: A Classification of the Finite Rings with Unity by Computable Means. (Under the direction of Kwangil Koh.)

SungDong Kim, Fiber and Polymer Science
Pusan, Korea

Dissertation: Synthesis of Bulky and Rigid Spin Probes and a Study of Their Mobility in Nylon 6 Film by ESR Spectroscopy. (Under the direction of Harold S. Freeman, Richard D. Gilbert and Ralph McGregor.)

Kenneth Daniel Konyha, Biological and Agricultural Engineering
Urbana, Illinois

Dissertation: A Medium Scale Watershed Model: Field Hydrology Coupled to Open Channel Flow. (Under the direction of R. Wayne Skaggs.)

Anup Kumar, Computer Engineering
Bareilly, India

Dissertation: On Evaluation of Reliability and Integrated Performance-Reliability Parameters for Distributed Systems. (Under the direction of Dharma P. Agrawal.)

Miau-Rong Lee, Physiology
Taipei, Taiwan, Republic of China

Dissertation: Transfer and Expression of a Bacterial Marker Gene by Retrovirus Vector in Avian Germ Line and Somatic Cells. (Under the direction of Robert M. Petters and Ruth M. Shuman.)

Yoonsang Lee, Aerospace Engineering
Kwang-Ju, Korea

Dissertation: Aerodynamic Interaction of Counter Rotating Propellers. (Under the direction of Robert T. Nagel.)

Jan Kent Lewandrowski, Economics
Harvard, Massachusetts

Dissertation: A Regional Model of the U. S. Softwood Lumber Industry: Including the Role of Price Expectations, the Role of Finished Product Inventory and the Impacts of Trade Restrictions on Canadian Softwood Products. (Under the direction of Thomas J. Grennes and Michael K. Wohlgenant.)

Bruce Robert Locke, Chemical Engineering
Silver Spring, Maryland

Dissertation: Protein Purification by Counteracting Chromatographic Electrophoresis. (Under the direction of Ruben G. Carbonell and David F. Ollis.)

Edward Morris Lunk, Forestry
Ann Arbor, Michigan

Dissertation: An Evaluation of Responses of Cottontail Rabbits to Structure and Composition of Cover: Development and Testing of Habitat-use Models for a Generalist Species. (Under the direction of Arthur W. Cooper and Richard A. Lancia.)

Stephen Wayne Martinez, Economics and Statistics
Chesapeake, Virginia

Dissertation: The Optimal Dynamic Hedging Positions for Grain Producers before Harvest: A Case Study. (Under the direction of Peter Bloomfield and Kelly D. Zering.)

Sarah Jean Mason, Veterinary Medical Sciences
Raleigh, North Carolina

Dissertation: Modulation of MHC Molecules on Intestinal Epithelial Cells. (Under the direction of Philip B. Carter.)

Elizabeth Ford McElwain, Genetics
Hingham, Massachusetts

Dissertation: HMG Chromosomal Proteins and Low Molecular Weight Heat-shock Proteins of Wheat. (Under the direction of Steven L. Spiker and William F. Thompson.)

Betty Fleming McQuaid, Soil Science
New Orleans, Louisiana

Dissertation: Color in Relation to Chemistry and Mineralogy of Some Dark Red Ultisols and Brown Alfisols in the North Carolina Piedmont. (Under the direction of Stanley W. Buol.)

Ricardo Jose Melgar, Soil Science
Corrientes, Argentina

Dissertation: Nitrogen Utilization by Annual Crops in the Central Amazon. (Under the direction of Pedro Sanchez and Thomas J. Smyth.)

Walter James Miller, Psychology
Raleigh, North Carolina

Dissertation: Physiological Gains and Degree of Disease in a Cardiac Rehabilitation Setting. (Under the direction of Patricia F. Horan.)

Charles Paul Moehs, Genetics
Old Forge, New York

Dissertation: Histone Variants in Plants: Role in Histone Octamer Stability. (Under the direction of James W. Moyer and Steven L. Spiker.)

Daniel Jude Moore, Electrical Engineering
Claymont, Delaware

Dissertation: Integrated Optoelectronics by Selective Epitaxy of Compound Semiconductors. (Under the direction of Salah M. Bedair.)

José Dilmer Moreno-Mendoza, Crop Science
Bogota, Colombia

Dissertation: Temperate and Tropical Evaluation of Temperate Maize Lines Derived from Totally Photosensitive Materials. (Under the direction of Major M. Goodman.)

Anjali Sanjeev Nandedkar, Materials Science and Engineering
Durham, North Carolina

Dissertation: Atomic Structure of Dislocations and Interfaces in Semiconductor Heterostructures. (Under the direction of Jagdish Narayan.)

Mehran Nazemi, Mechanical Engineering
Raleigh, North Carolina

Dissertation: Hemodynamics and Particle Deposition in Artery Bifurcations with Implications to Atherogenesis and Surgical Reconstruction. (Under the direction of Clement Kleinstreuer.)

Timothy Richard Nolen, Chemical Engineering
Gadsden, Alabama

Dissertation: Selectivity Enhancement of Electroorganic Reactions under Periodic Control: The Reduction of Nitrobenzene on the Rotating Disk Electrode. (Under the direction of Peter S. Fedkiw.)

Dennis Jay Osborne, Soil Science
Waynesville, North Carolina

Dissertation: Soils and Landscape Elements in the Balsam Range of the Southern Blue Ridge. (Under the direction of Stanley W. Buol.)

Hakan Ozisik, Mechanical Engineering
Raleigh, North Carolina

Dissertation: Development and Implementation of an Open Loop Control Technique for High Speed Micropositioning in a Single Point Diamond Turning Process. (Under the direction of Richard F. Keltie.)

Daniel Pomp, Animal Science
Chicago, Illinois

Dissertation: Cryopreservation of Embryos from Generically Selected Mouse Lines. (Under the direction of Eugene J. Eisen.)

Johnny De-Wayne Powers, Chemical Engineering
Greensboro, North Carolina

Dissertation: Protein Purification by Affinity Ultrafiltration Using Small Unilamellar Liposomes. (Under the direction of Ruben G. Carbonell and Peter K. Kilpatrick.)

Anton Ladislaus Pressing, Physiology
Immenreuth, West Germany

Dissertation: Aspects of Endocrine and Ovarian Maturation during Puberty in the Gilt. (Under the direction of Gary D. Dial and Kenneth L. Esbenshade.)

John Michael Reed, Zoology
Lancaster, Pennsylvania

Dissertation: Some Aspects of Vertebrate Conservation, with Particular Attention to the Red-cockaded Woodpecker. (Under the direction of Phillip D. Doerr and Jeffrey R. Walters.)

Deborah Ann Tomaszewski Renzi, Psychology
Central City, Pennsylvania

Dissertation: Application of an Ecological Model of Child Maltreatment to High-risk Indicators in North Carolina. (Under the direction of N. William Walker.)

Joan Ayer Rodberg, Chemical Engineering
Calhoun, Kentucky

Dissertation: Metal-Radical Complexation: Results of ESR Studies and Implications. (Under the direction of Phooi K. Lim.)

Magdi Abdel Hamid Said, Materials Science and Engineering
Raleigh, North Carolina

Dissertation: Residual Porosity in Polymeric Latex Films (Under the direction of C. Maurice Balik and Abdel A. Fahmy.)

Peter Carl Schroeder, Entomology
California, Missouri

Dissertation: Effects of Select Soil-Arthropods on Nitrogen Fixation (Acetylene Reduction), Nodulation and Dry Matter Production of Soybean. (Under the direction of John W. Van Duyn.)

Chandana Senaratne, Chemistry
Colombo, Sri Lanka

Dissertation: Applications of AC Voltammetry: The Use of Second Harmonic Phase Angle Voltammograms to Measure Heterogeneous Kinetic Parameters. (Under the direction of Kenneth W. Hanck.)

Feng-Ran Sheu, Chemical Engineering
Ching-Shui, Taiwan, Republic of China

Dissertation: The Transport of Simple Gases through Aromatic Polyethers and Polyesters. (Under the direction of Rey T. Chern and Harold B. Hopfenberg.)

Yuan-Tay Shyu, Food Science
Taipei, Taiwan, Republic of China

Dissertation: Purification and Partial Characterization of a Novel Calcium-binding Protein from *Bacillus cereus* T Spores and Inhibition of Germination by Calmodulin Antagonists. (Under the direction of Peggy M. Foegeding.)

Wesley Davis Sing, Microbiology
Indianapolis, Indiana

Dissertation: Mechanisms of Phage Resistance Encoded by Conjugative Plasmids of Lactococci. (Under the direction of Todd R. Klaenhammer.)

Rajiv Kumar Singh, Materials Science and Engineering
Calcutta, India

Dissertation: Microstructure and Properties of Laser Deposited High- T_c Superconducting Thin Films. (Under the direction of Jagdish Narayan.)

Christopher Ward Smith, Soil Science
Redondo Beach, California

Dissertation: The Fertility Capability Classification System (FCC) - 3rd Approximation: A Technical Soil Classification System Relating Pedon Characterization Data to Inherent Fertility Characteristics. (Under the direction of Stanley W. Buol.)

Arun Ramaswamy Srivatsa, Materials Science and Engineering
Bangalore, India

Dissertation: Defects and Interfaces in Epitaxial and Amorphous Insulators. (Under the direction of Jagdish Narayan.)

Hon-Wei Syh, Nuclear Engineering
Taipei, Taiwan, Republic of China

Dissertation: Image Processing for Neutron Radiography. (Under the direction of Robin P. Gardner and Raymond F. Saxe.)

Todd Lewis Talarico, Microbiology
Oakmont, Pennsylvania

Dissertation: Characterization of the Production of an Antimicrobial Agent by *Lactobacillus reuteri*. (Under the direction of Walter J. Dobrogosz.)

Wayne Carl Thresher, Biochemistry
Big Flats, New York

Dissertation: Characterization of Macromolecular Interactions by High Performance Analytical Affinity Chromatography. (Under the direction of Harold E. Swaisgood.)

Alberto Daniel Venica, Wood and Paper Science
Las Varillas, Argentina

Dissertation: Soda-AQ Delignification of Hardwoods: Reactions, Mechanisms and Dissolved Lignin Characteristics. (Under the direction of Josef S. Gratzl.)

Jacqueline Michael Vrba, Genetics
Durham, North Carolina

Dissertation: Characterization of a Four Member *psbA* Gene Family from the Cyanobacterium *Anabaena* PCC 7120. (Under the direction of Stephanie E. Curtis and William F. Thompson.)

Gregory James Wadsworth, Genetics
Metairie, Louisiana

Dissertation: Molecular Biology of the Catalase Gene-Enzyme System of Maize: Gene Structure and Expression. (Under the direction of John G. Scandalios.)

Richard Alan Wahls, Aerospace Engineering
Raleigh, North Carolina

Dissertation: Development of a Defect Stream Function, Law of the Wall/Wake Method for Compressible Turbulent Boundary Layers. (Under the direction of Fred R. DeJarnette.)

Mark David Walters, Materials Science and Engineering
Durham, North Carolina

Dissertation: Radiation-induced Defect Phenomena in Thin Films of SiO_2 . (Under the direction of John J. Hren and Arnold Reisman.)

Yuh-Hwa Wang, Biochemistry
Taichung, Taiwan, Republic of China

Dissertation: A Functional and Structural Study of Translational Regulation of Ferritin mRNA. (Under the direction of Elizabeth C. Theil.)

Aaron David Weiss, Chemistry
Wilmette, Illinois

Dissertation: Studies of Augmented Flames for Analytical Atomic Spectrometry. (Under the direction of Charles B. Boss.)

Randy Gene Westbrooks, Botany
Gaffney, South Carolina

Dissertation: Regulatory Exclusion of Federal Noxious Weeds from the United States. (Under the direction of James W. Hardin and A. Douglas Worsham.)

Thomas Wiekpe, Crop Science
Mechanicsville, Maryland

Dissertation: Influence of Legume and Rye Mulches on No-till Flue-cured Tobacco, Soil Reception and Dissipation of Diphenamid, and Weed Suppression. (Under the direction of A. Douglas Worsham.)

Mark Lee Wildhaber, Zoology

Saint Louis, Missouri

Dissertation: Habitat Choice by Bluegills (*Lepomis macrochirus*) on the Basis of Feed and Temperature. (Under the direction of Larry B. Crowder and John M. Miller.)

David Wayne Wolff, Horticultural Science

Greensburg, Pennsylvania

Dissertation: Evaluation, Inheritance and Utilization of Tolerance to Bentazon Herbicide in Peppers (*Capsicum annuum* L.). (Under the direction of Wanda W. Collins and Thomas J. Monaco.)

Russell Dean Wolfinger, Statistics

Mansfield, Ohio

Dissertation: Rates of Convergence and Asymptotic Normality in Semiparametric Regression. (Under the direction of A. Ronald Gallant.)

Caifang Yin, Wood and Paper Science

Beijing, People's Republic of China

Dissertation: Characterization, Bacterial and Fungal Degradation, Dechlorination and Decolorization of Chlorolignin in the Bleach Plant Effluent. (Under the direction of Hou-min Chang and Thomas W. Joyce.)

Mark Anderson Young, Chemical Engineering

Asheville, North Carolina

Dissertation: Airlift Bioreactors: Experimental and Theoretical Analysis of Two-phase Hydrodynamics. (Under the direction of Ruben G. Carbonell and David F. Ollis.)

Manasses Kasse Yunmbam, Zoology

Ntong, Cameroon

Dissertation: The Efficacy of a Newly Discovered Antimicrobial Substance, Reuterin, against *Trypanosoma brucei brucei*. (Under the direction of John F. Roberts.)

Candidates for Degree May 12, 1990

Clark Raymond Alexander, Jr., Marine, Earth and Atmospheric Sciences
Inglewood, California

Dissertation: Modern Sedimentation in the Yellow Sea: Application to Geologic Models of Epicontinental-shelf and Macrotidal-mudflat Environments. (Under the direction of David J. DeMaster and Charles A. Nittrouer.)

Lina Shirish Amin, Biochemistry

Cary, North Carolina

Dissertation: Coupling Factor 1 from *Euglena gracilis*: Comparison of the E Subunits of Coupling Factor 1 from Mitochondria and from Chloroplast. (Under the direction of Joseph S. Kahn.)

Luiz Felipe Arauz, Plant Pathology

San Jose, Costa Rica

Dissertation: Studies on the Epidemiology and Control of *Botryosphaeria obtusa* on Apples. (Under the direction of Turner B. Sutton.)

Deogratias Artis Banks, Physiology

Kinston, North Carolina

Dissertation: The Effects of Reuterin, a Newly Discovered Antimicrobial Compound, on Mouse Myeloma Cells *in Vitro*. (Under the direction of John F. Roberts.)

Jean-Sébastien Brouard, Forestry

Quatre Bornes, Mauritius

Dissertation: Competition in Clonal Silviculture. (Under the direction of Floyd B. Bridgwater and Bruce J. Zobel.)

James Gaylord Burkhart, Biochemistry

Apex, North Carolina

Dissertation: A Unique Bilirubin-UDP-Glucuronyltransferase Deficiency Related to Neonatal Jaundice in Mice. (Under the direction of Frank B. Armstrong.)

Anthony Gerard Calamai, Physics

Toms River, New Jersey

Dissertation: Radiative Lifetimes of Metastable Atomic Ions. (Under the direction of Charles E. Johnson.)

William Lawrence Carruthers, Psychology

Garner, North Carolina

Dissertation: Two Scales for Measuring Educators' Attitudes toward Computers. (Under the direction of Patricia F. Horan and N. William Walker.)

Joseph Henry Carter III, Zoology

Southern Pines, North Carolina

Dissertation: Population Trends and Reproductive Success of the Red-cockaded Woodpecker on 3 Study Areas in the North Carolina Sandhills, 1980-1987. (Under the direction of Phillip D. Doerr.)

Kijoon Chae, Computer Engineering

Seoul, Korea

Dissertation: Performance Evaluation of Interconnected Heterogeneous Local Area Networks. (Under the direction of Arne A. Nilsson.)

Gao-Yuan Chen, Fiber and Polymer Science

Funing, People's Republic of China

Dissertation: Enhancement of Fiber Structure Formation Via Modification of Threadline Dynamics in the Melt Spinning Process. (Under the direction of John A. Cuculo and Paul A. Tucker, Jr.)

Tein Yaw David Chung, Electrical Engineering

Tao-Yuan, Taiwan, Republic of China

Dissertation: Design and Analysis of Manhattan Street Class of Doubly Linked Networks. (Under the direction of Dharma P. Agrawal.)

David Thomas Cobb, Zoology

Gibsonville, North Carolina

Dissertation: Impacts of Unnatural, Asynchronous River Flooding on the Habitat Use and Population Dynamics of a Wild Turkey Population along the Roanoke River, North Carolina. (Under the direction of Phillip D. Doerr.)

Randall Avery Craig, Psychology

Raleigh, North Carolina

Dissertation: Effects of Order of Study Modality on Visual and Haptic Performance: Implications for Cross-modal Transfer. (Under the direction of Slater E. Newman.)

Paul D. Curtis, Zoology

Perry, Ohio

Dissertation: Northern Bobwhite Quail Ecology in the North Carolina Sandhills. (Under the direction of Phillip D. Doerr.)

Jose Raul Davelouis McEvoy, Soil Science

Lima, Peru

Dissertation: Green Manure Applications to Minimize Aluminum Toxicity in the Peruvian Amazon. (Under the direction of Pedro A. Sanchez.)

Christopher Hallock Dietrich, Entomology

Martinsville, Virginia

Dissertation: A Revision of the Neotropical Treehopper Tribe Aconophorini (Homoptera: Membracidae). (Under the direction of Lewis L. Deitz.)

Rich Thomas Dobrowsky, Veterinary Medical Sciences

Pittsburgh, Pennsylvania

Dissertation: Production and Metabolism of Platelet-activating Factor during Porcine Endotoxemia: Quantitative Analysis by Thermospray Mass Spectrometry and the Metabolic Effect of Endotoxin on Plasma Acetylhydrolase Activity. (Under the direction of Peter J. Bentley and Neil C. Olson.)

Robert Philippe Durieux, Soil Science

Bergen, The Netherlands

Dissertation: Root Activity and Nutrient Uptake and Accumulation in Prolific and Nonprolific Corn. (Under the direction of Eugene J. Kamprath.)

James Andrew Duthie, Plant Pathology

Essex, Ontario, Canada

Dissertation: The Alfalfa Leafspot Pathosystem: Effects of Debris, Optimal Rates of Sampling and Associations among Leafspot Pathogens. (Under the direction of C. Lee Campbell.)

Cynthia Griffith Eayre, Plant Pathology

Hendersonville, North Carolina

Dissertation: Protection of Bean (*Phaseolus vulgaris*) Seedlings from *Rhizoctonia solani* with an Avirulent, Binucleate, *Rhizoctonia* Fungus. (Under the direction of Eddie Echandi.)

Kamal Ali Eljabaly, Physics

Hodeidah, Yemen

Dissertation: Oxidation of Silicon in an RF Coupled Plasma. (Under the direction of Arnold Reisman and Dale E. Sayers.)

Peter Campbell Ellsworth, Entomology

Longmeadow, Massachusetts

Dissertation: Temperature, Water and Diapause Effects on European Corn Borer Phenology in North Carolina. (Under the direction of Julius R. Bradley, Jr. and George G. Kennedy.)

Nathan Brooks Emery, Fiber and Polymer Science
Raleigh, North Carolina

Dissertation: The Inspection of Blue Denim Fabric with Computer Vision.
(Under the direction of David R. Buchanan and Hechmi Hamouda.)

Peter John Falter, Mechanical Engineering
Apex, North Carolina

Dissertation: Diamond Turning of Nonrotationally Symmetric Surfaces.
(Under the direction of Thomas A. Dow.)

Jon Taylor Fitch, Materials Science and Engineering
Raleigh, North Carolina

Dissertation: A Study of Local Atomic Structure and Thermal History in Thermally Grown and Remote PECVD Deposited SiO₂ Films. (Under the direction of Robert F. Davis and Gerald Lucovsky.)

Dorothy Anne Flannagan, Psychology
Richmond, Virginia

Dissertation: The Effects of Organization and Scripted Action on Children's Communication and Recall of Scenes. (Under the direction of Lynne Baker-Ward and Samuel A. Snyder.)

Thaddeus Raymond Gourd, Plant Pathology
Albuquerque, New Mexico

Dissertation: Differential Activity of Selected Nematicides on *Heterodera glycines* Races and *Meloidogyne* Species. (Under the direction of Kenneth R. Barker and Donald P. Schmitt.)

Johnny Rufus Graham, Civil Engineering
China Grove, North Carolina

Dissertation: An Investigation of the Relationship between Retroreflectivity, Luminance and Driver Perception of Roadway Markings. (Under the direction of Paul D. Cribbins and L. Ellis King.)

Frances Foreman Haga, Sociology
Black Mountain, North Carolina

Dissertation: Staying In or Getting Out: "Importation," Behavior, Coercive Program Assignment and Length of Stay in Juvenile Training Schools. (Under the direction of Elizabeth M. Crawford and Gary D. Hill.)

Tracy Michelle Halward, Crop Science
Raleigh, North Carolina

Dissertation: Utilization of Diverse Germplasm Resources as Part of a Comprehensive Peanut Breeding Program. (Under the direction of Johnny C. Wynne.)

Norihito Hamaguchi, Electrical Engineering
Mie, Japan

Dissertation: InGaAs/GaAsP Strained-layer Superlattices: MOVPE Growth and Applications. (Under the direction of Salah M. Bedair.)

Di Han, Industrial Engineering
Beijing, People's Republic of China

Dissertation: Computer Speech Recognition and Expert System Methods for Entering Chinese Characters to Computer. (Under the direction of Thom J. Hodgson and Michael G. Joost.)

Jeong-Whan Han, Physics

Seoul, Korea

Dissertation: Growth and Properties of $\text{Hg}_{1-x}\text{Cd}_x\text{Te}$ Alloys and Quantum Well Structures. (Under the direction of Jan F. Schetzina.)

Patrick Knowlton Worsham Howle, Botany

Florence, South Carolina

Dissertation: GTP-specific Pyrophosphorylation of Thiamin in Soybean [*Glycine max* (L.) Merr. cv. Ransom II]. (Under the direction of Roger C. Fites.)

Kuang-Yeu Hsieh, Materials Science and Engineering

Tainan, Taiwan, Republic of China

Dissertation: Growth, Characterization and Diffusion Induced Disorder-ing of III-V Semiconductor Superlattice. (Under the direction of Robert M. Kolbas and Ronald O. Scattergood.)

Chingyuang Albert Huang, Marine, Earth and Atmospheric Sciences

Taipei, Taiwan, Republic of China

Dissertation: A Mesoscale Planetary Boundary Layer Numerical Model for Simulations of Topographically Induced Circulations. (Under the direction of Sethu Raman.)

Natalie Louise Hubbard, Horticultural Science

Raleigh, North Carolina

Dissertation: Biochemical Regulation of Sucrose Accumulation in Musk-melon and Banana Fruits. (Under the direction of Steven C. Huber and David M. Pharr.)

William Edward Hutson, Psychology

Bowie, Maryland

Dissertation: Dissociation of Performance and Subjective Measures in Human-Computer Interaction: The Effects of Response Delay and Re-sponse Bias. (Under the direction of Donald H. Mershon.)

Nimal Newton Jayaratne, Civil Engineering

Gampaha, Sri Lanka

Dissertation: Resilient Behavior of Stabilized Subgrade Soils. (Under the direction of N. Paul Khosla and Philip C. Lambe.)

Melissa Charlene Joerger, Food Science

Newberg, Oregon

Dissertation: Cloning, Expression and Nucleotide Sequence of the Gene Encoding Helveticin J: A Bacteriocin Produced by *Lactobacillus heliveti-cus* 481. (Under the direction of Todd R. Klaenhammer.)

Ganesh Gopalkrishna Kamath, Food Science

Bombay, India

Dissertation: Investigation of Physico-chemical Basis for the Unique "Set-ting" Phenomenon of Alaska Pollack and Atlantic Croaker Surimi. (Under the direction of Tyre C. Lanier.)

Milton Kanashiro, Forestry

Belem, Para, Brazil

Dissertation: The Demographic Genetics of an Appalachian Stand of *Liri-odendron tulipifera* L. (Under the direction of Gene Namkoong.)

Sang Soo Kim, Physics
Seoul, Korea

Dissertation: Deposition of Amorphous Silicon and Silicon Based Dielectrics by Remote Plasma Enhanced Chemical Vapor Deposition: Application to the Fabrication of TFT's and MOSFET's. (Under the direction of Gerald Lucovsky.)

David Joseph Kropaczek, Nuclear Engineering
Clark, New Jersey

Dissertation: In-core Nuclear Fuel Management Optimization Utilizing Simulated Annealing. (Under the direction of Paul J. Turinsky.)

Chin Chin Lee, Horticultural Science
Rembau, Malaysia

Dissertation: Inflorescence Development and Cultural Production Practices of *Heptacodium jasminoides*. (Under the direction of Theodore E. Bilderback and Roy A. Larson.)

Dong-Myun Lee, Materials Science and Engineering
Seoul, Korea

Dissertation: Impurity Gettering by Misfit Dislocations and Precipitation Phenomena in Si/Si(Ge) Epitaxy. (Under the direction of George A. Rozgonyi.)

Jay Min Lee, Physics
Seoul, Korea

Dissertation: Photo-darkening Kinetics and Structural Anisotropic Modifications in the Chalcogenide Glass As_2S_3 : A Study of Kinetic X-ray Absorption Spectroscopy. (Under the direction of Michael A. Paesler and Dale E. Sayers.)

Zhongshan Li, Mathematics
Lanzhou, People's Republic of China

Dissertation: The Embedding of Rings in Regular Rings and π -Regular Rings. (Under the direction of Jiang Luh and Mohan S. Putcha.)

Robert Todd Lorenz, Microbiology
Salem, Oregon

Dissertation: Characterization of Aerobic Sterol-Exclusion in the Yeast, *Saccharomyces cerevisiae*. (Under the direction of Leo W. Parks.)

Chung-Cheng Lu, Botany
Taipei, Taiwan, Republic of China

Dissertation: Metabolic Activity in the Shoot Apical Meristem of *Nicotiana tabacum* during Flora Evocation. (Under the direction of Judith F. Thomas.)

Jar-Miin Luan, Biological and Agricultural Engineering
Taichung, Taiwan, Republic of China

Dissertation: On the Direct Confirmation of Hertz Contact Pressure Distribution during Viscoelastic Impact. (Under the direction of Roger P. Rohrbach.)

Mary Frances Mahalovich, Forestry
Gallup, New Mexico

Dissertation: Modeling Positive Assortative Mating and Elite Populations in Recurrent Selection Programs for General Combining Ability. (Under the direction of Floyd E. Bridgwater.)

Vera Katharina Marquardt, Mathematics
Worms, West Germany

Dissertation: Factoring the Group of Units of a Ring. (Under the direction of Mohan S. Putcha.)

Edward Joseph McCarthy, Biological and Agricultural Engineering
Simsbury, Connecticut

Dissertation: Modification, Testing and Application of a Hydrologic Model for a Drained Forest Watershed. (Under the direction of R. Wayne Skaggs.)

Myra Jerone McCrickard, Economics
Martinsville, Virginia

Dissertation: Real Business Cycle Models: Some Direct Evidence. (Under the direction of Douglas Fisher and John J. Seater.)

Sylvester Elliott McKay, Psychology
Raleigh, North Carolina

Dissertation: Psychosocial Competence, Adjustment to College and Academic Success of Learning Disabled Community College Students. (Under the direction of Patricia F. Horan.)

Deborah Ann McLeod, Veterinary Medical Services
Fuquay-Varina, North Carolina

Dissertation: Modification of Radiation Damage in the Canine Kidney by Hyperthermia: A Histologic and Functional Study. (Under the direction of Donald E. Thrall.)

Mark Richard McMurtry, Horticultural Science
Ellsworth, Maine

Dissertation: Performance of an Integrated Aquaculture-Olericulture System as Influenced by Component Ratio. (Under the direction of Ronald G. Hodson and Douglas C. Sanders.)

Julie Ray Meyer, Plant Pathology
Minneapolis, Minnesota

Dissertation: The Effect of Soil Factors on the Incidence and Severity of Black Root Rot of Burley Tobacco, Caused by *Thielaviopsis basicola*. (Under the direction of C. Lee Campbell and H. David Shew.)

Lisa Maurer Must, Veterinary Medical Sciences
Newark, Delaware

Dissertation: Identification and Characterization of *pilE*, a Gene Determining Receptor Binding of *Escherichia coli* Type 1 Pili. (Under the direction of Paul E. Orndorff and Donald G. Simmons.)

Edward Roy Myers, Materials Science and Engineering
Springfield, Illinois

Dissertation: Influence of Point Defects on Electronic Properties in Low Energy Ion Implantation. (Under the direction of John J. Hren.)

Willard Wayne Neel, Mechanical Engineering

Raleigh, North Carolina

Dissertation: A Ray Tracing Computative Method for Architectural Spaces Incorporating Interference Phenomena. (Under the direction of Thomas H. Hodgson.)

Sue Ellen Nokes, Biological and Agricultural Engineering

Canal Fulton, Ohio

Dissertation: Simulation of the Development and Control of Cercospora Leafspot and the Effect on Peanut Growth. (Under the direction of James H. Young.)

John Edward Olsen, Materials Science and Engineering

Hoboken, New Jersey

Dissertation: Infrared Internal Reflection Spectroscopy of SiO₂ on Silicon. (Under the direction of John H. Hren.)

Nur Mevlude Onvural, Economics

Ankara, Turkey

Dissertation: Economics of Scale and Economies of Scope in North Carolina Savings and Loan Institutions. (Under the direction of Douglas K. Pearce.)

Girish Anant Pai, Fiber and Polymer Science

Bombay, India

Dissertation: The Creep and Fatigue Lifetime Behavior of Poly (ethylene terephthalate) Monofilaments. (Under the direction of Subhash K. Batra and Solomon P. Hersh.)

Gregory Newton Parsons, Physics

Baldwinsville, New York

Dissertation: Preparation and Physical Properties of Hydrogenated Amorphous Silicon Thin Films. (Under the direction of Gerald Lucovsky.)

Elizabeth Rose Pedersen, Psychology

Pittsboro, North Carolina

Dissertation: A Predictive Model of Post-retirement Life Satisfaction. (Under the direction of Charles D. Korte.)

John Michael Polo, Microbiology

Big Flats, New York

Dissertation: Molecular Analysis of Sindbis Virus Pathogenesis. (Under the direction of Robert E. Johnston.)

Todd Morsman Powers, Psychology

Raleigh, North Carolina

Dissertation: Perceived Opinion Projection in Others: An Extension of False Consensus Research. (Under the direction of James E. R. Luginbuhl.)

Leonard Franklin Register II, Electrical Engineering

Beaufort, North Carolina

Dissertation: Path-integral Monte Carlo Methods for Ultrasmall Device Modeling. (Under the direction of Michael A. Littlejohn.)

Ashraf Hassan Riad, Civil Engineering

Cairo, Egypt

Dissertation: The Shear Strength Controlling the Stability of Cut Slopes in Residual Soil. (Under the direction of Philip C. Lambe and Harvey E. Wahls.)

Naraporn Rungsimuntakul, Fiber and Polymer Science
Bangkok, Thailand

Dissertation: Effects of Incorporation of Masked Isocyanates on the Moisture Absorption and Mechanical Properties of Epoxy Resins. (Under the direction of Raymond E. Fornes and Richard D. Gilbert.)

Jon Paul Rust, Fiber and Polymer Science
Raleigh, North Carolina

Dissertation: Fiber Assembly in Friction Spinning. (Under the direction of Peter R. Lord.)

Joselito Alcantara Sarreal, Materials Science and Engineering
Manila, Philippines

Dissertation: Microstructural Development in Rapidly Solidified Fe-Al-C and Fe-Al-C Based Alloys. (Under the direction of Carl C. Koch.)

Gregory Damian Sayles, Chemical Engineering
Berkeley, California

Dissertation: Modeling and Analysis of Immobilized Cell Catalysts and Reactors. (Under the direction of David F. Ollis and Steven W. Peretti.)

Sujit Sharan, Materials Science and Engineering
Ranchi, Bihar, India

Dissertation: Nature of Defects and Defect Reduction Processing in GaAs/Si Heterostructures. (Under the direction of Jagdish Narayan.)

Suresh Rajbhat Siddhanti, Biochemistry
Bombay, India

Dissertation: Studies on the Mechanism of Metabolic Regulation by Dietary Fat. (Under the direction of Samuel B. Tove.)

Eric David Sills, Nuclear Engineering
Kannapolis, North Carolina

Dissertation: Thermal-hydraulic Modelling of Nuclear Reactor Systems Using Advanced Architecture Computers. (Under the direction of J. Michael Doster.)

Paul Chace Smithson, Soil Science
Winston-Salem, North Carolina

Dissertation: Aluminum Chemistry of Forested Soils Subjected to Acidic Inputs. (Under the direction of Wayne P. Robarge and Sterling B. Weed.)

Sreeram Srinivasan, Materials Science and Engineering
Madras, India

Dissertation: Crack Growth Resistance Effects in Erosion and Local Impact Damage of Ceramics. (Under the direction of Ronald O. Scattergood.)

Virginia Lessmann Stonick, Electrical Engineering
Pittsburgh, Pennsylvania

Dissertation: Global Methods of Pole/Zero Modeling for Digital Signal Processing Using Homotopy Continuation Methods. (Under the direction of S. Thomas Alexander.)

Ching-Tzong Sune, Electrical Engineering
Taipei, Taiwan, Republic of China

Dissertation: Radiation Damage Phenomena in Insulated Gate Field Effect Transistors. (Under the direction of Arnold Reisman.)

Maylon Bruten Taylor II, Fiber and Polymer Science
Raleigh, North Carolina

Dissertation: The Kinetics of Radiation-induced Inverse Emulsion Polymerization of Vinylpyrrolidone. (Under the direction of Richard D. Gilbert and Vivian T. Stannett.)

Craig Steven Turchi, Chemical Engineering
Dallas, Texas

Dissertation: Heterogeneous Photocatalytic Degradation of Organic Water Contaminants: Kinetics and Hydroxyl Radical Mechanisms. (Under the direction of David F. Ollis.)

John Alexander Turner, Nuclear Engineering
Winston-Salem, North Carolina

Dissertation: Transient Two-phase Subchannel Analysis on Advanced Architecture Computers. (Under the direction of J. Michael Doster.)

Mark Steven Udevitz, Biomathematics and Statistics
Raleigh, North Carolina

Dissertation: Change-in-ratio Methods for Estimating the Size of Closed Populations. (Under the direction of Cavell Brownie and Kenneth H. Pollock.)

Maureen Odilia Vandermaas, Psychology
Charlotte, North Carolina

Dissertation: The Effects of Anxiety on Children's Memory for Dental Procedures. (Under the direction of Lynne Baker-Ward and Thomas M. Hess.)

José Leonidas Villalobos, Animal Science
San Jose, Costa Rica

Dissertation: Diet Quality, Tiller Dynamics and Total Nonstructural Carbohydrates in Flaccidgrass (*Pennisetum flaccidum* Griseb) under Three Defoliation Regimes. (Under the direction of Joseph C. Burns.)

Saranath Laksman Weerakoon, Civil Engineering
Embilmeewala, Sri Lanka

Dissertation: Behavior of Slender Reinforced Concrete Columns Subjected to Biaxial Bending. (Under the direction of Shuaib H. Ahmad.)

Thomas Joseph Weingartner, Marine, Earth and Atmospheric Sciences
Fairbanks, Alaska

Dissertation: Aspects of the Mass, Momentum and Heat Balances of the Central Equatorial Atlantic Ocean. (Under the direction of John M. Morrison and Robert H. Wiesberg.)

Terry Ann Wheeler, Plant Pathology
Stephentown, New York

Dissertation: The Effects of Soil Moisture on the Populations Dynamics of *Meloidogyne incognita* and Growth of *Nicotiana*. (Under the direction of Kenneth R. Barker and Sally M. Schneider.)

Garry Wong, Toxicology
Sacramento, California

Dissertation: The Steroid 16 α -Hydroxylase Gene Family (P450IID9): Structure and Regulation. (Under the direction of Ernest Hodgson.)

Stephen Ray Workman, Biological and Agricultural Engineering
Lynchburg, Ohio

Dissertation: Development and Application of a Preferential Flow Model.
(Under the direction of R. Wayne Skaggs.)

Ke-Jun Xie, Mechanical Engineering
Shanghai, People's Republic of China

Dissertation: A Boundary Element Method (BEM) Solution for a Fractional Operator Modeled Viscoelastic-Acoustic System. (Under the direction of Larry H. Royster.)

Abdul-Aziz Yakubu, Applied Mathematics
Accra, Ghana

Dissertation: Global Stability, Bifurcation and Chaos in Discrete Competitive Systems. (Under the direction of John E. Franke.)

Yuri Takeshima Yamamoto, Genetics
Ibaraki, Japan

Dissertation: A Tobacco Root-specific Gene: Characterization and Regulation of Its Transcription. (Under the direction of Mark A. Conkling and Charles S. Levings.)

Fred Hinnant Yelverton, Crop Science
Black Creek, North Carolina

Dissertation: The Use of Activated Carbon to Reduce Phytotoxicity of Herbicides to Flue-cured Tobacco (*Nicotiana tabacum*). (Under the direction of Gerald F. Peedin and A. Douglas Worsham.)

Andrew Gerard Yersin, Physiology
Baltimore, Maryland

Dissertation: Observations on Physiological Alterations in the Turkey Poult during *Bordetella avium* Infection. (Under the direction of Frank W. Edens.)

Ji Zhang, Statistics
Shandong, People's Republic of China

Dissertation: Bootstrap Methods for Tests about Covariance Matrices. (Under the direction of Dennis D. Boos.)

UNDERGRADUATE ALUMNI DISTINGUISHED PROFESSORS

E. M. Afify	Mechanical & Aerospace Engineering	College of Engineering
Richard L. Porter	Materials Science and Engineering	College of Engineering
Robert L. Beckmann	Botany	Agriculture and Life Sciences
Kevin R. Pond	Animal Science	Agriculture and Life Sciences
Richard C. Dillman	Microbiology, Pathology, and Parasitology	College of Veterinary Medicine
Christopher R. Gould	Physics	Physical and Mathematical Sciences

GRADUATE ALUMNI DISTINGUISHED PROFESSORS

Fred R. DeJarnette	Mechanical & Aerospace Eng.	College of Engineering
Stanley Buol	Soil Science	Agriculture & Life Sciences

OUTSTANDING TEACHERS FOR 1989-90

<i>Name</i>	<i>College and Department</i>
S. Thomas Alexander	Engineering Electrical & Computer Engineering
Gary B. Blank	Forestry Forestry
Roy H. Borden, Jr.	Engineering Civil Engineering
John T. Brake	Agricultural & Life Sciences Poultry Science
John C. Cornwell	Agricultural & Life Sciences Animal Science
John M. Cullen	Veterinary Medicine Microbiology, Pathology and Parasitology
Paul R. Fantz	Agricultural & Life Sciences Horticultural Science
J. Conrad Glass, Jr.	Education and Psychology Adult & Community College Education
Claudia B. Kimbrough	Humanities & Social Sciences Economics & Business
Russell E. King	Engineering Industrial Engineering
Eric C. Klang	Engineering Mechanical & Aerospace Engineering
Robert H. Martin, Jr.	Physical and Mathematical Sciences Mathematics
Marianetta Porter	School of Design Design
Allen J. Riordan	Physical and Mathematical Sciences Marine, Earth, and Atmospheric Sciences
Gary T. Roberson	Agricultural & Life Sciences Biological & Agricultural Engineering
Tony K. Stewart	Humanities and Social Sciences Philosophy and Religion
James E. Swiss	Humanities and Social Sciences Political Science and Public Administration
Charles Tomasino	Textiles Textile Engineering, Chemistry, and Science

Awards for Achievement 1989-1990

COLLEGE OF AGRICULTURE AND LIFE SCIENCES

Agri-Life Council Outstanding Club Member Awards:

- African American Science and Health Society:* G. Bernard Taylor, Fayetteville
Agronomy: Ronald E. Kelly, Candor
Animal Science: Craig S. Gentry, Eunice
Biochemistry: Victoria M. Zula, Durham
Biological and Agricultural Engineering: Science Curriculum—Randall K. Page, Elon College; Technology Curriculum—Donald L. Wells, Henderson
Biology: Margaret D. Kirby, Cary
Agricultural Economics: Philip C. Shivar, Dudley
Food Science: Jaime Mullerat, Raleigh
Horticultural Science: Laurie J. Smith, Kitty Hawk
Microbiology: Sharon R. Collins, East Bend
National Agri-Marketing Association: Elizabeth A. Palmer, Raleigh
Poultry Science: Aaron D. Sheffield, Magnolia
Pre-Medical and Pre-Dental: Lori M. Langdon, New Hill
Pre-Veterinary: David W. Linzey, Raleigh
Wildlife Biology: James D. Dick, Summerfield

Agronomy

- Senior Highest Scholastic Average in Agronomy:* Felicia Cope, Clemmons
American Society of Agronomy Award, Most Outstanding Senior: Ronald E. Kelly, Candor
Agronomy Club Leadership Award: Ronald E. Kelly, Candor

Animal Science

- Most Outstanding Club Member:* Karen Pegram, Belews Creek
Most Outstanding Senior: Carol Greene, Collettsville
American Society of Animal Science Undergraduate Awards: Stephanie V. Baker, Mt. Olive; Christine J. Campbell, Lewisville; Staci H. Canterbury, Cary; Maria C. Casey, Raleigh; Scott R. Chandler, Mount Gilead; Carlton A. Cook, Raleigh; Susan M. Creed, Columbia, SC; Matthew W. Ehinger, Stedman; Joyce C. Greene, Collettsville; Catherine H. Hamilton, Raleigh; Christine D. Hannaway, Raleigh; Kenneth L. Howe, Jr., Gastonia; Lucille Kohut, Raleigh; Laurie A. Lang, Kernersville; Elisa D. Long, Huntersville; Meredith Mahon, Fuquay-Varina; Bridgett C. Mitchell, Greensboro; Laura H. Phillips, Mocksville; Alice L. Terrell, Charlotte; Vicki Y. Wilson, Henderson; Danny L. Wright, Polkton

Biochemistry

- Outstanding Biochemistry Student Awards:* Rebecca Bullard-Dillard, Garner; Michelle L. DuBois, Dallas, TX; Margaret E. Guest, Durham

Biological and Agricultural Engineering

- American Society of Agricultural Engineers, Student Honors Awards—North Carolina Student Engineering Branch of the American Society of Agricultural Engineers:* Anders S. Johansson, Salisbury
North Carolina Student Mechanization Branch of the American Society of Agricultural Engineers: Robert S. Clontz, Troutman

Food Science

- B. M. Newell Award:* Ginger D. Goodman, Salisbury
Forbes Leadership Award: Ginger D. Goodman, Salisbury
Ambrosia Chocolate Top Scholar Award: Jaime Mullerat, Raleigh
Crouch Scholastic Achievement Award: Lisa C. Shaw, Gaithersburg, MD

Horticultural Science

Outstanding Senior Horticulturist Award: Dane K. Fisher, Salisbury

Microbiology

Most Outstanding Student: Martina M. Gratzl, Raleigh

Poultry Science

T. T. Brown Poultry Science Club Award: Aaron D. Sheffield, Magnolia

Zoology

Most Outstanding Student: Katherine B. Meadows, Lewisville

SCHOOL OF DESIGN

ARCHITECTURE AWARDS

The American Institute of Architects School Medal: Criteria: scholastic achievement, character, and promise of professional ability. *Sarah Duncan Drake*

The American Institute of Architects Certificate of Merit: Criteria: scholastic achievement, character, and promise of professional ability. *Andrew James Iatridis*

North Carolina Chapter of The American Institute of Architects Award for Design Achievement: Criteria: greatest promise in design by a Master of Architecture degree recipient. *Andrew James Iatridis*

Richard Green Award for Design Achievement: Criteria: greatest promise in design by a Bachelor of Architecture degree recipient. *Wojciech Szaszor*

Architecture Faculty Award for Design Achievement: Criteria: greatest promise in design by a Bachelor of Environmental Design/Architecture degree recipient. *Jerry Darrell Fink*

Alpha Rho Chi Medal: Criteria: ability for leadership . . . willing service to his or her school . . . and program . . . promise of real professional merit through attitude and personality. *Michael Ross Kersting*

Walter Hook Award: Criteria: appreciation for and creative application of technology in architecture. *Elias John Torre*

DESIGN AWARDS

Design Faculty Book Awards: Criteria: Outstanding academic achievement and design excellence in the Department of Design. *Mary Lou Herring, Aly Gamil Khalifa, Laura Suzanne Lambie, Amy Rebecca Milne*

LANDSCAPE ARCHITECTURE AWARDS

The American Society of Landscape Architects Certificate of Honor: Criteria: scholarship and accomplishment in skills related to the art and technology of Landscape Architecture. *Timothy William Maloney, Iana Joy Doherty, Joseph Michael Orthosky, Jr.*

The American Society of Landscape Architects Certificate of Merit: Criteria: scholarship and accomplishment in skills related to the art and technology of Landscape Architecture. *Ralph James Cox, Jr., Joanne Benton Rubino, Catherine Jane Parrington Voorhees*

Landscape Architecture Faculty Honor Award: Criteria: outstanding academic performance and design excellence in Landscape Architecture. *Peter Truesdell Lucey*

Landscape Architecture Faculty Service Award: Criteria: for dedicated service in support of faculty and students in the Department of Landscape Architecture. *Julia Haynsworth Barringer*

Landscape Architecture Faculty Book Award: Criteria: Total scholastic performance and professional promise. *Shanda Harrelson Davenport*

PRODUCT/VISUAL DESIGN AWARDS

Product Design Book Awards: Criteria: scholastic achievement in Product Design. *Stephen E. Wald* (Undergraduate), *Richard C. Stone* (Graduate)

Outstanding Undergraduates in Visual Design Book Awards: Criteria: scholastic achievement in Visual Design. Allison Grey Lackey, Tanya Ann Quick

Outstanding Graduate in Visual Design Book Award: Criteria: scholastic achievement in Visual Design. Max Justin Beck

American Institute of Graphic Arts Raleigh Chapter Student Award: Criteria: outstanding senior in Visual Design. Nathaniel Williams

Industrial Designers Society of America Student Merit Award: Criteria: outstanding Graduate in Product Design. A. Reneau VanLandingham

COLLEGE OF EDUCATION AND PSYCHOLOGY

Education Council Outstanding Senior Awards:

Agricultural Education: Margaret Donohue Hardin, Hillsborough

Health Occupations Teacher Education: Linda Rogers, Raleigh

Marketing Education for Teachers: Koren Wilkerson, Raleigh

Mathematics Education: Margery Leigh Hollis, Charlotte

Middle Grades Language Arts and Social Studies: Melissa Isaacs, Pinnacle

Psychology (outstanding graduating senior): Scott Alan Smith, Durham

Psychology (general option): Kim Rosan Tousignant, Raleigh

Psychology (human resource development option): Mary Anna Willingham, Kenansville

Science Education: Melissa A. Ballington, Cary

Technology Education: Harden Ricci, Cary

Agricultural Education Awards to Most Outstanding Seniors:

Fall 1988: Keith Whitley, Hays

Spring 1990: Troy Coggins, Denton

Durwin M. Hanson Achievement Award: Ricky Warren, Clinton

Epsilon Pi Tau-Leadership Award: David J. Scott, Kinston

Mathematics Education, Outstanding Graduate Teaching Assistant: Glenda R. Haynie

Mathematics Education Service Award to Outstanding Teaching: Glenda Johnson Moody

Psychology Department Award for Service to the Department: Teresa Dent Hill, Raleigh; Evan Eugene Upchurch, Maggie Valley

Psychology Department Award for Academic Achievement: Joseph Clair McClintock, Raleigh

Psychology Department Award for Research: Sumedha Gupta, Raleigh

Science Education Service Award to Outstanding Teacher: Rachel Suzanne Parks

COLLEGE OF ENGINEERING

Engineering Senior Award for Scholarly Achievement: Kimberly A. Monroe, Wadsworth, OH (Industrial Engineering)

Engineering Senior Award for Citizenship and Service: Kristin Keidel, Muskegon, MI (Mechanical & Aerospace Engineering)

Engineering Senior Award for Leadership: Jane Stover, Charlotte (Textile Engineering, Chemistry & Science)

Engineering Senior Award for the Humanities: Alicia Elizabeth Speight, Grimesland (Civil Engineering)

Biological and Agricultural Engineering

Agri-Life Council Outstanding Club Member Award for Biological and Agricultural Engineering: Science Curriculum: Randall Keith Page, Elon College

American Society of Agricultural Engineers Student Honor Award: North Carolina Student Engineering Branch of ASAE: Anders S. Johansson, Salisbury

Chemical Engineering

Outstanding Contribution to Chemical Engineering Department: Bedie M. Roberts

NSDEA Graduate Fellowship: Gavin Gaynor

Schoenborn Graduate Student Award: Jim Hunter

Civil Engineering

Associated General Contractors Award to Outstanding Senior in Civil Engineering/Construction Option: Scott E. Rushing

Outstanding Teaching Assistant Awards: Gregory S. Briggs, Stillwater, OK; Steve D. Carpenter, Arden; James D. Holt, Raleigh

ASCE Outstanding Seniors: Charles William Moyres, Spring Lake; Gretchen Ann Hobbs, Hobbsville; Cindy A. Satterwhite, Winston-Salem; Matthews Day Foster, Cary

Grigg Mullen Award for Exceptional Service to ASCE: Charles Moyers, Spring Lake

Computer Science

Scholarly Achievement: Alan G. Bishop, Raleigh

Citizenship and Service: Timothy E. Figgins, Raleigh

Humanities: Stacy A. Hilliard, Baltimore, MD

Leadership: Douglas M. Seay, Cary

Electrical and Computer Engineering

William L. Everitt Awards: Daniel W. Carlson, Raleigh; Darren A. Shakib, Lexington, KY

Outstanding Electrical Engineering Senior Award: Michael E. Bailey (December 1989), Salisbury; Daniel W. Carlson, Raleigh

Outstanding Computer Engineering Senior Award: Sui O. Yee (December 1989), New Bern; George E. Hague, Wilkesboro

Outstanding IEEE Student Award: Donna L. Brown, Washington

Furniture Manufacturing and Management

Rudolph Willard Award, Outstanding Senior in Furniture Manufacturing and Management: J. David Vaughan, Galax, VA

Industrial Engineering

Outstanding Industrial Engineering Student: Kimberly A. Monroe, Wadsworth, OH

Materials Science and Engineering

Outstanding Senior Award: Warren Andrew Thomas

NSF Engineering Research Center Award for Advanced Electronic Materials Processing: Vincent Harold Hammond

Mechanical and Aerospace Engineering

ASME Outstanding Student Member: Clair Hobbs Barrett, Raleigh

Charles T. Main Award for Region IV of ASME: Bradley Mains, Recipient for 1989-90, Scottsville; Clair Hobbs Barrett, Nominee for 1990-91, Raleigh

ASME National Student Section's Committee Service Award: Sherri Fishel

AIAA President's Certificate: Rebecca Squires

Nuclear Engineering

Outstanding Nuclear Engineering Senior Award: Kevin Roland, Eden

Textile Engineering

Harry Ball Honor Award: Jane E. Stover, Charlotte

Murray Frumkim Honor Award: John Timothy Roberts, Burlington

Textile Veteran's Association Honor Award: Robert J. Bender, Fayetteville

COLLEGE OF FOREST RESOURCES

Forestry

Biltmore Work Scholarships: David P. Blevins, Langley AFB, VA; Robert B. Kidd, Siler City; James W. Overby, High Point; Victor H. Parrish, Raleigh; Robert D. Sturgill, Raleigh; Philip E. Whitlow, Raleigh

Ralph Bryant Scholarship Awards: Henry A. Randolph, Cameron; James N. Slye, Mocksville

E. F. Conger Scholarship: Christopher F. Dumas, Raleigh; Jerold M. Bryant, Raleigh

James L. Goodwin Work Awards: Barbara Boothroyd, Asheville; Melanie A. Burke, Raleigh; Stephen M. Daniels, Greensboro; Thomas J. Margo, Raleigh; Michael M. Petruncio, Raleigh; David B. Powell, Jr., Franklin, VA; James F. Shern, Raleigh

James L. Goodwin Academic Scholarship Awards: Melanie A. Burke, Raleigh; Paul T. Eriksson, Ledgewood, NJ; Edward L. Liverman, Roanoke Rapids; Deborah L. Nahikian, Raleigh; James N. Slye, Mocksville; Forrest H. Teague, Jr., Goldsboro; Randall F. West, Jr., Andrews

Jonathan Wainhouse Memorial Scholarship Awards: David B. Powell, Jr., Franklin, VA; James F. Shern, Derwood, MD; Michi C. Vojta, Naperville, IL

John M. and Sally Blalock Beard Forestry Scholarship: Joseph R. Byrd, Durham; Richard A. Crouse, Winston-Salem; Bradley C. Duckworth, Rocky Mount; Jeffrey M. Leonard, Wake Forest; Matthew B. Vincett, Raleigh

Hofmann Forest Academic Scholarship Awards: Derek E. Halberg, Charlotte; Thomas W. Harrill, Arden; Henry A. Randolph, Jr., Cameron; Joanne L. Stumpf, Raleigh; Bruce White, Durham

College of Forest Resources Scholarships: Christopher N. Duncan, Martinez, GA; Johann A. Mosley, Kinston

Wood and Paper Science

Pulp and Paper Science Technology

Albright & Wilson Americas Inc. Scholarship: Harvey William White, Cary

Alonzo Aldrich Scholarship: John Gerhard Michael, Warner Robins, GA

Dietrich V. Asten Scholarship: Kevin D. Hamilton, Winston-Salem

Betz Laboratories, Inc. Scholarship: Chris David Jones, Palatka, FL

M. Lebbly Boinest, Jr. Scholarship: Daniel Edwin Pouchot, Achilles, VA

David & Doris Bossen Endowment: William Gregory Fullenwider, Lewisport, KY

E.J. & S.W. Brickhouse Scholarship: Robert Shean Cumbee, Supply

William E. Caldwell Scholarship: John William Graves, Pensacola, FL

Lawrence H. Camp Scholarship: Douglas Frank Falls, Franklin, VA.

Caraustar Industries Scholarship: Bradley Lee Evans, Rome, GA.

J. Robert Carpenter Scholarship: Heidi Lyn Musser, Clifton Forge, VA.

Drs. Li-Sho & Lee-Fun Chang Scholarship: Bradford Scott Barron, Raleigh

Charles W. Coker, Sr. Scholarship: Patrick Wayne Low, Rock Hill, SC

W. V. Cross & Nalco Scholarships: Robert Glenn McRee, Rome, GA

E.E. Ellis Scholarship: Jason Scott Cronin, Tell City, IN

John A. Heitmann, III Scholarship: Mitchell Alan Malcolm, Centerville, GA

Hercules, Inc. Scholarship: Gregory James Venditti, Monroe, CT

Robert G. Hitchings Scholarship: Mary Kathryn Harrison, Raleigh

IP/PPT Minority Scholarship: Darryl D. Raspberry, Pine Bluff, AR

James River Corporation Scholarship: George Edward Stubbins, Mooresville

Kamine Engineering Scholarship: Andrew Anthony Hobson, Asheboro

John R. Kennedy Scholarship: William A. Norris, Wilmington

Will P. Lovin Scholarship: Scott Alexander Hamilton, Waynesville

Hazard & Ada May Scholarship: Wade Edward Rushing, Winston-Salem

John M. May, Jr. Scholarship: James Anthony Johnson, Stanley

Nalco Chemical Co. Scholarship: Kevin Jerome Gramelspacher, Tell City, IN

George E. Oakley Scholarship: Andrea L. Nelson, Macon, GA

Sture G. Olsson Scholarship: John Leon Windley, Hayes, VA

C.C. Peters Scholarship: Kathryn Lynn Bennett, Wilmington

PIMA-SE Scholarship: Kevin Correll Christian, Raleigh

PIMA-Southern Scholarship: Mark Allen Hayter, Williamsburg, VA

PIMA-Southern Scholarship: Christopher James Hayter, Williamsburg, VA

Rector/Ascraft Scholarship: Melinda Joyce McDaniel, Warner Robins GA

Salesmen's Soc. PIMA Scholarship: Michael Steven Jackson, Shelby

Salesmen's Soc. PIMA Scholarship: Dennis William Singleton, Canton

Harry H. Saunders Scholarship: Steven R. Spencer, Midlothian, VA

Dr. Fred B. Schelhorn Scholarship: Jeffrey Gordon Thomas, Jamestown

Michael Sherman Scholarship: Lisa Joan Greene, Hawesville, KY

Showlin Family Scholarship: Christopher William Blenk, Savannah, GA

Ray Smith Scholarship: Larry Scott Jackson, Ashland, VA

Dwight Thomson Scholarship: Charles Kevin Haney, Canton
Tidewater Construction Co. Scholarship: Edward Allen Turner, Franklin, VA
Union Camp Corporation Scholarship: Ronald Lee Smith, Brunswick, GA
Vinings Chemical Scholarship: John Charles Single, Atlanta, GA.

Wood Science & Technology

The Roy Carter Scholarship: Reynolds W. Trull, Henderson
Thomas Forshaw Scholarship: Jack M. Ragan, III, Raleigh
Weyerhaeuser Company Scholarship: Clyde G. Arnette, Raleigh; Frederick S. Carter, Jr., McLeansville; Jerry M. Floyd, Chadburn; Gregory R. Kasten, Edwardsville, IL; Bernard T. Rose, Seaboard; James E. Rubino, Raleigh; Talya R. Selbst, Wendell; James A. Snyder, Monroe, NY; Paul W. Westbrook, Raleigh

COLLEGE OF HUMANITIES AND SOCIAL SCIENCES

Highest Scholastic Achievement Awards

College of Humanities and Social Sciences: Thomasina Stikeleather, Kernersville
Division of Economics and Business: Thomasina Stikeleather, Kernersville (Accounting); Elizabeth Price Feild, Belmont (Business Management); Christopher W. Johnson, Fuquay-Varina (Economics)
Department of English: Judith E. Darling, Garner
Department of Foreign Language and Literatures: James M. Matson, Stonesville
Department of History: Kim Ray Annas, Wake Forest
Department of Multidisciplinary Studies: Tiffany Paige Martz, Durham
Department of Philosophy and Religion: John M. Bishop, III, Raleigh
Department of Political Science and Public Administration: Christopher W. Johnson, Fuquay-Varina
Department of Sociology and Anthropology: Ellen Christine Miller, Landis, (Sociology); Margaret Burden Seagroves, Raleigh (Social Work)
Department of Speech Communication: Joseph T. Gaitens, Cary
Outstanding Senior Awards: Joseph T. Gaitens, Cary; Genette Lynn Robinson, Greensboro

COLLEGE OF PHYSICAL AND MATHEMATICAL SCIENCES

College Awards to Outstanding Seniors

Scholarship: David Alston Chesnutt, Turkey
Citizenship and Service: Stephen Andrew Hall, Louisburg
Humanities: Hok Kim, Raleigh
Leadership: Scott Thomas Gray, Raleigh
Research: Charles John Brabec, Raleigh
Phi Kappa Phi Graduate Fellowship Award: Judith Elaine Bush, Winter Park, FL

Departmental Awards

Chemistry

The North Carolina Institute of Chemists' Award: Susan Ellen Kuharcik, Wilmington
The Merck Index Awards for Scholastic Achievement Award: Deborah Marie Berg, Raleigh; Steven Philip Manuli, Mebane
The CRC Press Freshman Chemistry Achievement Award: Pamela Marie Meads, Elizabeth City
The 1990 Undergraduate Award in Analytical Chemistry: Krista Kasdorf-Connard, Raleigh

Physics

Outstanding Graduating Seniors in Physics: Michael Jennings Bennett, Columbus, OH; Charles John Brabec, Raleigh; Darin Thomas Cox, Raleigh
Freshman Physics Studentship: Danene Groenke, Charlotte
Herbert L. Owen Scholarship: John Boney, Wilmington

Statistics

Outstanding Graduating Senior in Statistics: Jeffrey Travis Morgan, Raleigh

F. E. McVay Scholarship: Meredith Carson Dunning, Raleigh

Outstanding Teaching Assistant Awards: Dominique Latour, Raleigh; Susan Melissa Starr, Raleigh

Academic Achievement Awards: Jorge Sierra-Cavazos, Cary; Graciela Gonzalez-

Farias, Cary; Tonya Lynn Etchison, Raleigh

Gertrude Mary Cox Fellowship Award: Tonya Lynn Etchison, Raleigh

Mathematics

Outstanding Graduating Senior in Mathematics: Candace Ruth Somers, Raleigh

John Cell Scholarship: Wendy Ellen Sense, Raleigh

Mary Alice and Hubert V. Park Scholarship: Pamela Jane Vehling, Raleigh;

Adam Guy Fitzgerald, Raleigh

Jack Levine-Charles Anderson Award: Havish Koorapaty, Raleigh

Charles Anderson Scholarship: David Ethan Mills, Cary

Charles F. Lewis Scholarship: Mark Robert Sinopoli, Raleigh

Mrs. Roberts C. Bullock Scholarship: Robert Benton Armstrong, Jr., Raleigh

The Maltbie Award: Elizabeth Jones, Raleigh; Andres S. Ravenna, Raleigh

Lowell S. Winton Graduate Award: Abdul-Aziz Yakubu, Washington, DC

Marine, Earth and Atmospheric Sciences

Outstanding Graduating Seniors in Geology/Geophysics: Jerry Lee Burgess, Wheaton, MD; Stephen Andrew Hall, Louisburg

Outstanding Graduating Senior in Meteorology: Mototaka Nakamura, Raleigh

Freshman Scholarship in Geology (1989-90): Robert J. Starzynski, Charlotte

Sophomore Scholarship in Geology (1989-90): Matthew Z. Cromer, Durham

Outstanding Teaching Assistant Awards:

Geology: John M. Brown, Raleigh;

Meteorology: Robert A. Rozumalski, Raleigh

COLLEGE OF TEXTILES

Joseph D. Moore Honor Award: Kentley B. Hester, Gastonia

Harry Ball Honor Award: Jane E. Stover, Charlotte

Lawrence Iason Honor Award: Leah R. Caviness, Lakeview

Chester H. Roth Honor Award: To be announced

John M. Reeves Scholarship: Steven K. Benson, Winston-Salem

Murray Frumkin Honor Award: John Timothy Roberts, Burlington

Textile Veterans Association Honor Award: Robert J. Bender, Fayetteville

John E. Reeves Award: Robert E. Earp, Raleigh

Donald F. McCullough Award: Charles F. Hollar, Newton Grove

John N. Gregg Award: Frederick Mark Stone, Salisbury

American Association of Textile Chemists & Colorists Award: James Gary Hough,

Fuquay-Varina

Phi Psi Textile Fraternity Award: Anne W. Sinkler, Raleigh

American Association for Textile Technology Award: Jennifer L. Smith, Laurinburg

Sigma Tau Sigma Scholarship Fraternity Award: To be announced

Kappa Tau Beta Student Leadership Award: Carrie Schurecht, Barrington, IL

Delta Kappa Phi Textile Fraternity: Suzanne D. Smith, Charlotte

AAMA - Apparel Student of the Year: To be announced

Henry A. Rutherford Honorary Award: Carole D. Lundberg, Garner

Dean's Award: Kentley B. Hester, Gastonia

ALUMNI ATHLETIC AWARD

Krista Kilburn

PHI KAPPA PHI ACHIEVEMENT AWARDS

Seniors

Jonas Marc Batten
David Alston Chesnutt

Katherine Burgan Meadows
Kimberly Ann Monroe

NCSU Nominee for National PHI KAPPA PHI Fellowship Award: Judith Elaine Bush

Honorable Mention: Darin Cox

GOLDEN CHAIN HONOR SOCIETY MEMBERS FOR 1989-90

Susan Elizabeth Brooks
Stephen Price Cook
Laura Beth Darien
Teresa DeLoatch
Chandana Ganguli
Terri Lynne Hefner
Jeffrey Allen Joines
Katherine Burgan Meadows
Stephanie Darrice Porter
Miriam Graham Preston
Anne Elizabeth Stubbins

THE HONOR SOCIETY OF PHI KAPPA PHI, GRADUATING SENIOR MEMBERS

December, 1989

Robert G. Blanton III
Gregory E. Bottomley
Charles John Brabec
Randall Glenn Bright
Patrick L. Combettes
Judith Ellen Darling
Gregory K. Daugherty
Susan Watkins Davis
Verna Arthur Edwards
Margaret Patricia Fels
Dane Kinard Fisher
Linda Adrienne Fry
Robert F. Gansman
Krishna K. Ginpall
Karen Michelle Grady
Wade Eric Jackson
David Carroll Jeffers
Christopher W. Johnson

Renu Pra Karamchandani
Karen I. Kitchens
Marian Davis Larrea
Ronald Gerald Lindsay
James Matthew Matson
Mary E. McKnight
Katherine B. Meadows
Ellen Christine Miller
Bernie Paul Pearce
Jeffrey Scot Ricks
Cynthia Siira Robbins
Scott Ernest Rushing
Margaret E. Thompson
Kyle Evan Troxell
Jacqueline Wheelaghan
Helen Hopson Yokeley
Pamela Denise Young

May 1990

Kim Ray Annas
Luis Felipe Arauz
Selena Lee Armistead
John Lewis Avent
Cynthia Ann Ballenger
Melissa Ann Ballington
Timothy Scott Barlow
Jonas Marc Batten
Robert Kevin Blackburn
Jack Wayne Bowling, Jr.
Frank Joseph Brauns
David William Bray
Lisa Gayle Brooks

Susan Elizabeth Brooks
Lisa Yvette Bryan
Joel Kirk Budd
Douglas L. Bunting, Jr.
Silvia Elena Buntinz
Judith Elaine Bush
Patricia R. Butcher
Anna Michelle Byrd
Dara Quayle Caricofe
Daniel Walter Carlson
Maria C. Casey
Ugur Celikkan
Alan Richard Chappel

David Alston Chesnutt
Joseph Jerome Cione
Troy Eugene Coggins
Elizabeth Hastings Conroy
Felicia Adair Cope
Lewis Norman Cornwall
Darin Thomas Cox
Virginia Gayle Davis
Duane Allen Decapite
Glenn Dale Detweiler
Hadjinic Devetsikiotis
Iana Joy Doherty
Janet Lee Dow

Sarah Duncan Drake
 Robert P. Durieux
 David Brian Eason
 Pamela Sue Erwin
 Jerome Eric Estoye
 Muriel I. Evans
 Joseph Thomas Gaitens
 Chandana Ganguli
 Rebecca T. Garrison
 Robert W. Gay, Jr.
 Jeffrey Alan Glasser
 Joanne E. Galsford
 Joyce Carol Greene
 John Richard Griggs
 Margaret E. Guest
 Marion Susanne Hackney
 George Eric Hague II
 Scott A. Hamilton
 Laura Kay Hardin
 Reid Vick Harris III
 David Bryan Hash
 James William Hauser
 Edward Barry Hill
 Laura Eve Hinrichs
 David James Holcombe
 Theresa Ann Hurban
 Tamara Yvette Jackson
 Joann Marie Jennings
 John Theodore Johnson
 Sandra Anne Justis
 Krista Kasdorf-Connard
 Kathryn D. Kesler
 Rebecca Diane Kesler

Bryan Dampier King
 Jill K. Krantz
 Susan Ellen Kuharcik
 Linda Louise Leaver
 Wiley Jones Loflin
 L. Dean Mason II
 Hazel B. Matthews III
 Virginia Janet McDonald
 Lynn Marie McGoogan
 John Gerhard Michael
 William E. Milholen II
 Kimberly Ann Monroe
 Joseph Norman Morris
 Mark Allen Morris
 Gary Christopher Moyer
 Nancy Neff
 Sue Ellen Nokes
 Anthony Jackson Norris
 Clint Townsen Nygaard
 Dale A. O'Neal
 Anthony Willard Payne
 Brian Keith Pearce
 Jeannie Marie Pegg
 Dana Michelle Reeves
 Kimberly Beth Respess-Sadler
 Brian James Riley
 Bedie Marie Roberts
 Steven John Russ
 Liane Elizabeth Salmon
 Manojit Sarkar
 Susan Barnett Sawyer
 Talya Rachel Selbst
 Darren Arthur Shakib

Geoffrey Neil Sifrin
 Ann Marie Simmons
 Joseph Conrad Sloop
 Crystal Renee Smith
 Steven Wayne Smith
 Candace Ruth Somers
 Crystal Lynn Spivey
 Jerry Ronald Sprague
 Thomasina Stikeleather
 Jane Elizabeth Stover
 David Olive Strickland
 Jo Murphree Szontagh
 Sairaju Tallavarjula
 Arles Allen Taylor
 Mark Thomas Taylor
 Patricia Gause Terrien
 Cheryl H. Theriault
 Warren Andrew Thomas
 Lori Renee Toth
 Kim Elizabeth Tripp
 Maureen O. Vandermaas
 Catherine J. Voorhees
 Dewey Craig Waddell
 Stephen Elliott Wald
 Merry Carol Ward
 Gail H. Webster
 Rose Casanave White
 Christina Marie Whitley
 Charlotte M. Wilkinson
 Wanda C. Williams
 Amy Louise Wood
 Stephen Ray Workman
 Sui Oi Yee

ARMY ROTC AWARDS

MS Class 4

Superior Cadet: Ivan D. Evans

Society of American Military Engineers: James Wescott

American Defense Preparedness Association: Stephen J. Roach

AFCEA Honor Certificate: Christopher L. Thompson

Reserve Officers Association: Anthony R. Hale

American Legion-General Military Excellence/Ranger Challenge Cert.: Kevin L. Simmons

American Legion-Scholastic Excellence: Jeffery Lackey

AUSA History Award: David M. Carpenter

George C. Marshall/Ranger Challenge Certificate: John W. Brennan, Jr.

Daughters of the American Revolution Award: Colleen S. McCloskey

General Dynamics Award: Robert Yauger

Ranger Challenge Certificate: Earl N. Frizzell, Jr.

NCSU Certificate of Appreciation: Norman P. Walls

NCSU Certificate of Appreciation: David Jones

NCSU Certificate of Appreciation: Jill M. Kitzinger

NCSU Certificate of Appreciation: Synthia H. Sweere

NAVY ROTC AWARDS

The SECNAV Distinguished Midshipman Graduate: Kristin E. Keidel

The Marine Corps Association Award: Michael S. Sailer

The VFW Achievement Award: Michael S. Sailer

The Sons of the American Revolution Medal: Scott W. Syme

The Fleet Reserve Association Award: Scott M. Parrish

The General Dynamics Award: Kristin E. Keidel

The American Defense Preparedness Association Award: Kristin E. Keidel

DEPARTMENT OF AEROSPACE STUDIES (AFROTC) AWARDS

Society of the War of 1812 Award: Torrey D. Woodhouse

American Legion Scholarship Award: Todd N. James, Jonathon R. Gillis

American Legion General Military Excellence Award: Daniel G. Talbot, Lida M. Pilotta, Benjamin R. Carlson, Gregory M. Lafferty

Daughters of the American Revolution Award: Lance Avery

Daughters of Founders and Patriots Award: Charles J. Law

American Veterans Award: Dorinda L. Humphries

Reserve Officers Association Award: Andre Bigford, Kevin S. Slaughter, Roger G. Gonzalez

American Defense Preparedness Association Award: Ashley D. Salter

Military Order of World Wars Award: Stanley P. Rosen, Jeremy A. Patton, Aaron J. Aubrecht

Veterans of Foreign Wars Award: Charles E. Perusse

National Sojourners Award: Jason L. Roberts

The Retired Officers Association Award: Mark W. Johnson

Sons of Confederate Veterans Award: Robert T. Riedell

Sons of the American Revolution Award: Wesley B. Davis

General Dynamics Award: Todd B. Sanders

Army ROTC Commissionees

MAY 1990

John W. Brennan, Jr.	Springfield, VA
Wesley S. Buchanan	Galax, VA
Michael F. Burns, III	Fayetteville
David M. Carpenter	Raleigh
Leon C. Cooper	Fayetteville
Jeffrey J. Durr	Rockville, MD
Ivan D. Evans	Calgary, Alberta, Canada
Georges L. Fattal	Gaithersburg, MD
Earl N. Frizzell, Jr.	Cullowhee
Darryl Godwin	Wade
Anthony R. Hale	Aulander
Joel C. Horton	Springfield, VA
David Jones	Rockingham
Jeffrey N. Killian	Hickory
Kevin M. Klimczyk	Olean, NY
Jeffery Lackey	Statesville
Tracey M. Lawrence	Pope Air Force Base
Jill M. Litzinger	Reno, Nevada
Colleen S. McCloskey	State College, PA
Jeffrey S. Nelson	Fayetteville
Darrell W. Parnell	Abbeville, SC
Stephen J. Roach	Hayesville
Pamela E. Rogers	Matthews
Karen E. Schroeder	Fort Leonard Wood, MO
Wayne E. Schronce	Belmont
Kevin L. Simmons	Mt. Airy
Synthia H. Sweere	Atlanta, GA
Christopher L. Thompson	Wilson
Norman P. Walls	Elkin
Michael W. Welch	Ft. Lauderdale, FL
Robert Yauger	Cameron
James Wescott	High Point

Navy ROTC Commissionees

MAY 1990

Jeffrey Richard Alexander	Pittsford, NY
Christopher Allen Chrislip	Newton
William Allen Curlee	Martinsville, VA
William Hirschmann Haiges	Lancaster, PA
Kristin Elizabeth Keidel	Muskegon, MI
Scott Morgan Parrish	Hickory
James Bruce Runyon	Hopkinsville, KY
Michael Scott Sailer	Danville, VA
Scott Webster Syme	Shelby
Stanley Jefferson Wall	Fuquay-Varina

Air Force ROTC Commissionees

MAY 1990

Andre Bigford	Fayetteville
Steven M. Blair	Lenoir
Jonathan B. Blake	Sanford
Steven E. Lisowe	Raleigh
John J. Lomick, Jr.	Bressemer
Richard E. Hallbeck	Candler
William K. Rogers	Pisgah Forest
Ashley D. Salter	Jacksonville
Dustin P. Smith	Vass
Wade A. Stone	Baker, OR
Daniel G. Talbot	Islip, NY
Donald H. Whitley	Dudley

1990 COMMENCEMENT

ACKNOWLEDGEMENTS

The following non-University organizations have contributed significantly to the success of our commencement.

Mr. Frank Greathouse, Owner
Realizations, Inc., Raleigh, N.C.

Design and Implementation
of Stage Backdrop

Mr. Wade C. Miller, Jr., Owner
Sound Engineering, Asheboro, N.C.

Sound Systems



NORTH CAROLINA

Agricultural Institute



University Student Center

North Carolina State University

May 11, 1990

T W E N T Y - N I N T H
A G R I C U L T U R A L I N S T I T U T E
E X E R C I S E S O F G R A D U A T I O N

College of Agriculture and Life Sciences

Durward F. Bateman, Dean

Presiding

May 11, 1990

3:00 p.m.

*PROCESSIONAL

*INVOCATION.....The Reverend Charles E. Hocking
St. Pauls Episcopal Church
Cary, North Carolina

ADDRESS.....Mr. James A. Graham
Commissioner of Agriculture
Raleigh, North Carolina

AWARDING OF DIPLOMAS.....Durward F. Bateman, Dean
James L. Oblinger, Associate Dean and
Director of Academic Affairs

Jon F. Ort, Assistant Director
of Academic Affairs and Director of
the Agricultural Institute

CONFERRING OF DEGREES.....Larry K. Monteith
Interim Chancellor
North Carolina State University

MOVING OF THE TASSELS.....Salutatorian—Class of 1990

REMARKS.....Larry K. Monteith

STUDENT COMMENCEMENT SPEAKER.....Jennifer L. Dunnagan

RECOGNITION OF MARSHALS.....Durward F. Bateman, Dean

*BENEDICTION.....The Reverend Charles E. Hocking

*RECESSIONAL

Reception Immediately Following the Graduation Ceremony

*Please Stand

AGRICULTURAL INSTITUTE GRADUATES

May 11, 1990

AGRIBUSINESS MANAGEMENT

★		Mark Andrew Brewer
		Joseph Delandar Briley, Jr.
		Parran Broome Briscoe
	+	Roy Hunter Cobb
★★		Jennifer Leigh Dunnagan
	+	Clayton Chadwick Honeycutt
★		Jeffrey Lloyd Jones
★		Robert Lee Williford, Jr.

AGRICULTURAL MECHANIZATION AND MANAGEMENT

★		Kenneth Darin Myers
★★	+	Michael Harold Tedder

FIELD CROPS TECHNOLOGY

★		Andy Scott Adkins
★★	§ +	Charles Howard Brothers, Jr.
		Jason Kale Hedgecock
★		Robert Eldridge Jones
		Mark Edward Van Staalduinen

FOOD PROCESSING, DISTRIBUTION, AND SERVICE

	+	Martha Denise Alexander
★		John Morgan Boyette
★		Jonathan Lloyd Morgan
★		Fred Monroe Rickman, Jr.

LIVESTOCK MANAGEMENT AND TECHNOLOGY

★	+	William Benjamin Adcock
★	§	Michael Aubrey Beal
★		John Willis Broughton, Jr.
★	§	Stephen Russell Collins
★★	•	George Washington Gordon
★		Trent Gordon Lowder
★		Wendell Holmes Murphy, Jr.
★		Brian Lee Parker
		Lisa Kathleen Pelletier
	+	Kim Quinn
	•	John Morgan Taylor
★★	§	Raymond Marc Taylor
	§	Lee Boyce Underwood
		Anthony Darren Whitlow
★★	§	Walter John Young

ORNAMENTALS AND LANDSCAPE TECHNOLOGY

★		Douglas Ross Baker
	§ + •	William Thomas Bass, IV
	+	James Wood Boone, Jr.
		Richard Armistead Conner
★	§	Crystal Diane Ferebee

ORNAMENTALS AND LANDSCAPE TECHNOLOGY (Cont.)

★	§		Michael Bryant Fisher
	§		Walter Brent Fisher
			Gregory Turner Hare
★★		•	Olivia Burton Kemp
★	§		Adam Starling Mason
★★	§		David Charles Penland
			David Spencer Stroup
★★		+	Adam Michael Swartz
			David Paul Warren

TURFGRASS MANAGEMENT

	§		Newton Derrick Beavers
★	§		Francis Scott Brittain
	§	+	Michael Keith Chapman
			Michael Kevin DeVane
★	§	+	James MacNealley Duff, Jr.
★			Ronnie Dale Edmonds
			Charles Fredrick Falls
		+	Susan Beaman Geddie
★★	§	+	Timothy Alan Harkleroad
★	§	+	Rodney Edward Hine
★★			Robert Jerome House
★	§	+	Howard Arnold Hunt
★★	§	+	Karl Mason Lewis
			Joseph William Martikke
★		+	Steven Wilford Murphy
	§	+	Nelson Major Norwood
		+	Mark Samuel Price
	§		Benjamin Mark Snell
			Conly Morgan Stephenson, Jr.
★★			Randy William Tetterton
★★			Perry Montgomery Walker
★			Michael Dean Willis

DOUBLE MAJORS

★★	§	+	Jeffrey Wayne Carter
			Jason Scott Flowers
	§		Jeffrey Macon Gann
★	§		Lori Beth Glenn
		+	Arthur Eugene Helton, III
	§		James Robert Jones, Jr.
	§		Robert Stuart Littleton
★★	§	+	Alton Bernard Parker, Jr.
		#	Jesse Clinton Phillips, Jr.
			David Nelson Rinehart
			Ramon L. Yarborough, Jr.

- ★★ High Honors
- ★ Honors
- § Agribusiness Concentration
- + Graduated December, 1989
- In Absentia
- # Graduated December, 1989 and May, 1990

MARSHALS

Andrew Eugene Arnold

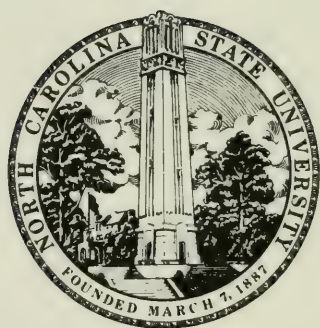
Keith Kesler Beck

Jeffrey Lynn Page

Andrea Darlene Bradshaw


Deanne Lynette Dotson

Mickey Douglas Holland



HECKMAN
BINDERY INC.



 **SEP 91**

N. MANCHESTER,
INDIANA 46962

